“OUTCOME ANALYSIS IN LOWER LIMB AMPUTATIONS FOLLOWING TRAUMA”

Dissertation submitted to

M.S. DEGREE-BRANCH II ORTHOPAEDIC SURGERY

THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY

CHENNAI, TAMILNADU

APRIL 2018

CERTIFICATE

This is to certify that this dissertation **"OUTCOME ANALYSIS IN LOWER LIMB AMPUTATIONS FOLLOWING TRAUMA"** is a bonafide record of work done by **DR.K.ARUN PRASANTH,** during the period of his Post graduate study from June 2015 to August 2017 under guidance and supervision in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-600003, in partial fulfilment of the requirement for **M.S.ORTHOPAEDIC SURGERY** degree examination of The Tamilnadu Dr.M.G.R Medical University to be held in April 2018.

Prof.R.Narayanababu
M.D.,DCH
Dean
Rajiv Gandhi Govt. General Hospital,
Madras Medical College,
Chennai – 600 003.

Prof. N.Deen Muhammad Ismail,
M.S Ortho., D.Ortho.,
Director & Professor of Orthopaedics,
Institute of Orthopaedics&Traumatology,
Madras Medical College,
Chennai – 600 003.

DECLARATION

I declare that the dissertation entitled **"OUTCOME ANALYSIS IN LOWER LIMB AMPUTATIONS FOLLOWING TRAUMA"** submitted by me for the degree of M.S ORTHO is the record work carried out by me during the period of November 2016 to September 2017 under the guidance of **Prof .N.DEEN MUHAMMAD ISMAIL, M.S.Ortho., D.Ortho.,** Director, Professor of Orthopaedics, Institute of Orthopaedics and traumatology, Madras Medical College, Chennai. This dissertation is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfilment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2018.

Place: Chennai
Date:

Signature of the Candidate
(Dr. K. ARUN PRASANTH)

Signature of the Guide
Prof.N. DEEN MUHAMMAD ISMAIL,M.S.Ortho., D.Ortho.,
Director, Professor of Orthopaedics,
Institute of Orthopaedics and Traumatology,
Madras Medical College, Chennai.

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INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI 600 003

EC Reg.No.ECR/270/Inst./TN/2013
Telephone No.044 25305301A
Fax: 011 25363970

CERTIFICATE OF APPROVAL

To
Dr.K. Arunprasanth
Post Graduate in M.S. Orthopaedic Surgery
Institute of Orthopaedics & Traumatology
Madras Medical College
Chennai 600 003

Dear Dr.K. Arunprasanth,

The Institutional Ethics Committee has considered your request and approved your study titled **"OUTCOME ANALYSIS IN LOWER LIMB AMPUTATIONS FOLLOWING TRAUMA " NO. 18112016.**

The following members of Ethics Committee were present in the meeting hold on **01.11.2016** conducted at Madras Medical College, Chennai 3

1.Dr.C.Rajendran, MD.,	:Chairperson
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11.Tmt.J.Rajalakshmi, JAO,MMC, Ch-3	: Lay Person
12.Thiru S.Govindasamy, BA.,BL,High Court,Chennai	: Lawyer
13.Tmt.Arnold Saulina, MA.,MSW.,	:Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

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INTRODUCTION

Amputation is a life-changing surgery. Amputation can be described as the removal of an extremity by surgery or trauma. If amputation is taken as a surgical measure, it is used to control pain or disease process in the affected limb. Amputation is one of the most common acquired disabilities. [1]. National Sample survey (NSS), 58th round 2002 estimated the prevalence of locomotor disability around 51%. Prevalence rates have shown declining trends during 1991-2002 for all types of disability except locomotor disability. [2]

There is an association between the age and cause of amputation. Upto age of 60 years, trauma and malignancy remains the major causes of amputation.[3] In the western world, peripheral vascular disease with or without diabetes mellitus accounts for 80-90% for all amputation. Amputations following trauma are either constant or declining in developed countries. The annual incidence of Lower limb amputations per 1,00,000 population is 500 in United States of America, 18-20 in Netherlands and 6.6 in France.[3]

On the other hand, trauma remains the major cause of amputation in developing countries. Trauma is the leading cause of amputation accounting for more than 70% in India.[2] The common traumas reported were road traffic accidents, railway accidents, burns due to fire, electrocution and chemical injuries. According to WHO, India has the highest number of road accidents in the world with 16.8 fatal injuries per 1,00,000 population and 38.9 non-fatal injuries per 1,00,000 population as

per the data from 2006.From these data, it can be postulated that trauma would be a significant cause of lower limb amputations.[3]

Following trauma, peripheral vascular diseases contribute around 27.7% for amputations due to the increase in aging population. Various studies conducted in India from Tamil Nadu, Andhra Pradesh, Punjab, West Bengal were consistent with trauma undoubtedly being the primary cause of amputation. [2]

Studies have shown males are more affected than females and most common age group being 21 to 40 years, involving the productive age group. Since the productive age group is mainly affected, they have issues with employment and financial issues in life besides adjustment in activities of daily living, personal care, recreation and social participation. It would also be a loss for the country, as these young people constitute potential contributors to the economy. [4]

Amputation itself is a change in body structure and has a great influence on the quality of life. On the other hand, amputation causes a variety of physical and psycho-social challenges which includes alterations in body image and lifestyle, changes in self-concept, impairments in physical functioning, using prosthesis, and feeling pain [1]. Ephraim et al.5 also reported that the greatest perceived barriers for individuals with limb loss were in the physical/structural environment.

Lower Limb amputations accounts for 94.8% of all amputations. Trauma is the second most common cause of locomotor disability in India accounting to 27% following polio [4] The resulting impairment and functional limitation among the

adolescent and young working age group significantly affects the employment and quality of life for the remaining period.

Graham et al., in National Amputee Statistical Database indicated that lower limb amputation is significantly more common than amputation of the upper limb; also it revealed that amputations of lower limbs occur in significantly greater numbers than do amputations of upper limbs. This result is further supported by Tseng et al. [1]

A person with lower limb amputation has a Permanent physical impairment (PPI) of 70% and above (except for through ankle and Syme's amputation). It means lower limb amputations not only affects people ability to walk, also the quality of life and body image perception which is significantly associated with mobility. [**2**] .

More incidence of lower limb amputations in younger patients as well as better developments in lower limb prosthesis design provide a great potential for enhancement of function in lower limb amputees compared to upper limb amputees.

Demet et al. study revealed that upper limb amputees reporting a better quality of life (compared to lower limb amputees) was primarily related to their responses pertaining to "physical disability, pain, and energy level".[1]

Of note is the finding that people with a lower limb prosthesis experience greater restriction in community activities and difficulty in joining in community activities than people with an upper limb amputation. This may be explained by the fact that people with a lower limb prosthesis are more likely to experience the physical environment as a barrier or challenge than people with an upper limb prosthesis. To

participate in community activities, sufficient mobility and the ability to gain access easily are important facilitating factors.[5]

Lower extremity amputation (LEA) cause serious physical disability and it is intuitive that adjustment to the conditions of amputation is impulsive to psychological distress. Depression in individuals with LEA was well investigated and many studies reported the prevalence rate of depression up to 45% among the study samples. The individuals with LEA showed relatively higher mortality rates due to cardiovascular diseases than the general population. A number of studies investigated and inferred a close relationship of depression with high blood pressure, diabetic condition, high cholesterol level, and obesity. From the above-mentioned studies, it may be argued that the individuals with LEA generally suffer from greater cardiovascular risks, and may also suffer from depression, although there is a dearth of empirical study among the individuals with LEA in this regard. Several quantitative studies demonstrated the association of increased social isolation and lower levels of perceived social support with lower perceived quality of life and higher levels of depressive symptomatology among people with amputation [6]

Though several factors like demography, injury characteristics, amputation level, post amputation surgeries influence the outcome, rehabilitation significantly improves the health and vocational prospects of persons with trauma related amputations. [7]

It is recommended that the participants receive a structured rehabilitation programme which is tailored according to the specific needs of people with limb amputation in order to bring an impact on their functional status and quality of life. [1]

It was strongly recommended that all amputees should be encouraged to undergo a well-structured rehabilitation program which includes physiotherapy, occupational therapy and vocational rehabilitation. Amputees must be encouraged for early ambulation by early provision of prosthesis [8]

AIM

The purpose of this study is to analyse the functional outcome in terms of physical, mental health, mobility, prosthesis use, of patients who sustained lower limb amputation following trauma. It also evaluates the effect of rehabilitation in improving the functional well-being of patients with amputations.

REVIEW OF LITERATURE

History

It is considered that the first account of amputation as a purposeful medical procedure is found in the Hippocratic treatise. The earliest amputations usually resulted in death from shock caused by blood loss or septicemia. Those who survived the operation itself often died in the early post-operative period because of infection and gangrene.

When antisepsis and anaesthesia were introduced in the mid nineteenth century, specific surgical techniques, tissue conservation and post-operative management became the focus of amputation surgery.

Antiseptic technique was introduced by Lord Lister in 1867.

Hippocrates was the first to use ligatures to attain haemostasis.

Hallstadt designed the earliest artery forceps and later Ambroise pare improved the design of artery forceps which decreased the mortality rates and created a more functional stump.

Morel's invention of tourniquet and Esmarch invention of rubber bandage made the job further easier.

The early amputations were of the guillotine type and the later modern concept of cutting skin, muscle, bone at different levels was popularised by Benjamin bell of Edinburgh.

Myoplasty was introduced by Burgess in 1956.

Myodesis was advocated by Weiss in 1960. [9]

Immediate post-operative prosthesis fit was introduced by Michael Berlemont.

The earliest reported use of prosthesis was by Hegistratus, a Persian soldier in 484 B.C, who was chained by the ankle and was awaiting the death penalty. He attempted to escape by cutting off one foot and later replaced it with a wooden one.

In India, first artificial limb centre was started in Defence Medical college, Pune.

Following that the next artificial limb centre was started in the southern part of India at Madras in 1965 in Madras Medical college. This was then shifted to Government Institute of Rehabilitation medicine in 1968.

Agrawal A. K, Goel M.K, Srivastava R.K conducted a retrospective study of 525 cases of lower limb amputees, attending the OPD of the rehabilitation and artificial limb centre and various rural clinics from January 1976 to March 1978. He reported that most of the cases were in the 3rd decade and males were more than females and trauma was the most common cause of amputation followed by peripheral vascular disease and neoplastic lesions. [12]

Weaver P.C and Marshall S.A. published their report on the function and social review of lower limb amputees. They reported that the conventional limb cannot be

used for heavy manual work especially where repeated soiling by water and mud is present. [10]

Radchiffe C.W. fabricated cosmetic cover for lower limb prosthesis, which is well acceptable to the amputees who rejected the prosthesis for lack of cosmesis. [11]

Balakrishna A Janardhanam K. in 1982 described the modification in below knee prosthesis for squatting and cross-legged sitting to suit the Indian amputee. [13]

Sharma K Satyendra. observed that the most outstanding feature of HDPE shank is that it provides resilience to the edge of the socket, which grips the stump during the swing phase and stance phase of gait cycle which is an ideal pre-requisite for below knee prosthesis. [14]

Ringh N.D. and Sethi P.K described the fabrication technique of above knee prosthesis and below knee prosthesis by using an aluminum and HDPE pipe which was supplied to the amputees the same day of taking the measurement and which also allows squatting and cross leg sitting suited to rural Indian culture. [15]

Pohjolainen T.A. et al published that 32 % of patient with lower limb prostheses did not use it at 1year of follow-up. They stated that several independent variables have to be assessed in order to determine the feasibility of prosthetic use & ambulation following lower limb amputation, especially in elderly amputees. [16]

Gafoor Abdul described Prosthetic use in lower extremity Amputees. Most of the patients were using prosthesis 5-8 hrs per day. They reported that in spite of various drawbacks, the acceptance of conventional Prosthesis was appreciable. [17]

Sree kumar M & Menon K.K, developed Calicut Prosthesis – In zonal limb fitting centre in Calicut Medical college. There was total replacement of wood with rigid polyurethane foam which minimize the weight and energy consumption. [18]

SAPP L. & Little C. E. stated that the average overall training time was 44.0 ± 26.5 days for an amputee. 65.5 % wear their prosthesis at least 9 hrs /day. 11.5 % Amputees wear at least 4 hrs /day & only 16.1% Amputees were not using their prosthesis. [19]

Chistersen B., Elleguard B. reported that the total training period for trans-tibial Amputees (unilateral) was a median period of 187 (86 to 314)days ~ 6 months. For Transfemoral Amputees of 217 (115 to 291) days ~ 7 months. [20]

Purry and Hannon analysed a group of 25 young adults rehabilitated after below knee amputees and concluded that most of them did well except for pain symptoms. [21]

Giodgiadis et al examined 18 post traumatic amputees and noted that 72 percent had pain and 39 percent had problems with skin breakdown. [21]

Walker et al compared 47 BKA 26 AKA 7 bilateral and concluded that, in the patient's view, below knee amputations fare no better than above knee amputation; both groups had similar severity of pain, wear prosthesis for similar length of time and also that there was no great difference in mobility. [21]

Smith and colleagues using data of 20 below knee amputees found that patient with traumatic amputations scored significantly lower in physical functioning and role limitations relative to normal age matched population. [22]

Millstein and colleagues reported 89% returned to work at some point, however 75% required a change in occupation. [22]

Curley and associates compared the employment rates of a sample of Vietnam veterans with limb amputations to those non-injured matched samples and concluded 69% were employed in contrast to 87%, in matched samples. [22]

Pezzin et al concluded that there are substantial physical deficits in trauma related amputees compared to the general population. In particular, physical functioning were about 40% below that of age and gender adjusted population norms. However no significant deficits were noted in scales measuring mental health and emotional functioning. [22]

Rotter et al analysed 45 BKA and 34 AKA and reported painful neuromas (12.5%) and phantom limb pain (12.5%). Prostheses durability was on average 3 years. The average period to resume work was 1 year for 60% of the cases. [23]

Geertzen et al analysed 70BKA 11TKA 50AKA and 7 bilateral amputees and reported that the chances of walking for 500m reduced with increasing age and more proximal level of amputation and was further affected in the presence of phantom and stump pain. [24]

Mackenzie et al analysed 161 lower limb amputees and reported BKA were better than AKA in terms of walking speed. However TKA group had worse sickness impact profile scores and walking speed compared to both groups. [25]

Helena burger et al studied about 223 patients after traumatic lower limb amputation and reported 74.2% were able to use their prosthesis for more than 7 hours a day, 52.2% are able to go outdoors without crutches and 57.8% climb more than 20 stairs per day. They concluded that successful fitting and usage of prosthesis promotes independent mobility. [26]

Pederson et al analysed 22 lower limb amputation following fractures and concluded most patients had acceptable functional results, however with increasing age, the chances of returning to work decreased and help demand increased. [27]

Livingston et al analysed 30 lower limb amputees and reported patients were able to perform activities of daily living and adapt to physical rehabilitation, whereas the rate of return to work was poor. [28]

Dawn Ehde reported 79% of patients reported phantom limb sensation and 72% reported phantom limb pain. They concluded that it affects a subset of population and has an impact on functioning and rehabilitation. [29]

Smith et al examined prosthetic history and functional outcome in of 20 traumatic unilateral BKA and reported, 12.5 hours of average use of prosthesis per day. [30]

Dillingham et al reported, that of 95% of traumatic amputees who had a prosthesis, only 43% were satisfied with prosthetic comfort, 19% used cane and 12.8% used crutches. [30]

Jowan G. Penn-Barwell through a meta-analysis study reported that patients with a through knee amputation have a better quality of life than those with above knee amputation and therefore supports maintaining maximum length whenever possible. [31]

SURGICAL ANATOMY OF THIGH [32]

MUSCLE GROUPS

Three muscle groups in thigh includes:

1. The adductors of hip are supplied by obturator nerve in the medial aspect of thigh. It includes Adductor longus, adductor brevis, adductor magnus and gracilis. Adductor magnus is a hybrid muscle supplied by the obturator and sciatic nerve and it adducts as well as extends the hip.
2. The extensors of the knee are supplied by the femoral nerve and occupies the anterior aspect of thigh. It includes the rectus femoris, vastus lateralis, vastus intermedius, vastus medialis and sartorius .
3. The flexors of knee (also extends the hip) are supplied by the sciatic nerve and lies in the posterior aspect of thigh. It includes biceps femoris, semitendinosus and semimembranosus.

The knee extensors are separated from the hip adductors by the thin medial intermuscular septum and from the knee flexors by the tough lateral intermuscular septum. The hip adductors and knee flexors are not separated by any intermuscular septum.

NERVES:

1. The sciatic nerve, which arises from the lumbosacral plexus, runs in the posterior aspect of thigh running deep to the long head of biceps and on

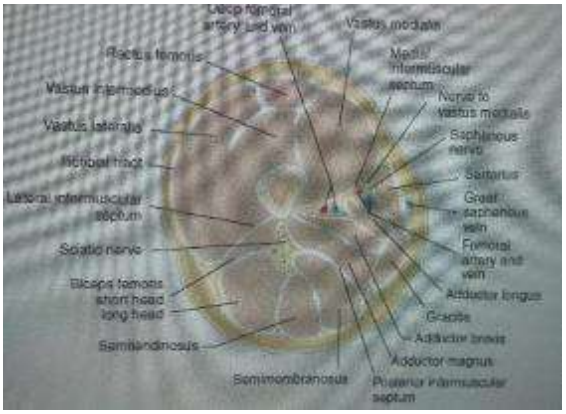
adductor magnus. It ends medial to the biceps, as the muscle crosses from the ischial tuberosity to head of fibula.

2. The femoral nerve, a branch of the lumbar plexus, divides and supplies the anterior aspect of thigh.

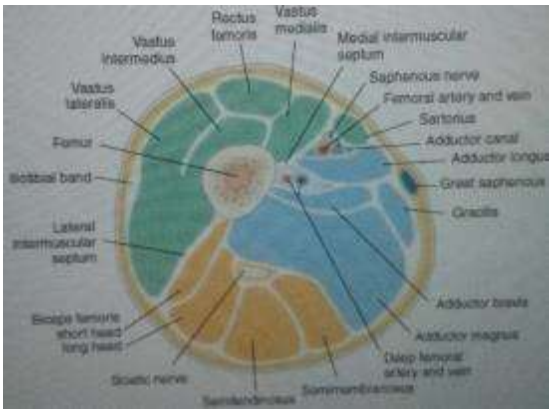
VESSELS:

1. The femoral artery enters the thigh under the inguinal ligament at the mid inguinal point, directly over the head of femur.
2. Then the artery travels over the iliopsoas and disappears at the bottom of femoral triangle beneath the Sartorius muscle and runs on adductor longus muscle. It lies in the sub-sartorial canal of Hunter. The canal lies between the extensors and adductors beneath the thick fascial layer of Sartorius.
3. The posterior wall is formed by the adductor muscles – adductor longus superiorly and adductor magnus inferiorly and the anterior wall by the vastus medialis.
4. The femoral artery finally about a handbreadth above the knee pierces the adductor magnus and joins the sciatic nerve in the popliteal fossa before entering the posterior compartment, where it lies medial to the sciatic nerve.
5. The femoral artery is lateral to femoral vein in the femoral triangle but medial to it in popliteal fossa.
6. In relation to the femur, femoral artery lies anterior to at it upper end, medial to it in the middle portion, and posterior to it at its distal end.
7. The profunda femoris artery arises from the femoral artery in the femoral triangle, arising from the lateral side before passing behind it quickly.

8. The adductor longus is sandwiched between the femoral artery anteriorly and profundal femoris artery posteriorly.
9. The medial femoral circumflex artery passes between the iliopsoas and the pectineus, to lie in the upper border of adductor longus . Then it winds in the interval between the quadratus femoris and the adductor magnus.
10. The lateral circumflex artery passes lateral to rectus femoris and divides into three branches
    - Ascending branch runs towards Anterior superior iliac spine in the interval between Sartorius and tensor fascia lata.
    - The transverse branch winds around the femur and anastamoses with the transverse branch of medial circumflex and contributes to the cruciate anastomosis.



At upper-third
Relationship of artery
To bone



At middle-third
Relationship of artery
to bone

At lower third relationship of artery to bone.

SURGICAL ANATOMY OF LEG [32]

Tibia remains subcutaneous in its whole length whereas the fibula is enclosed completely in muscle. Only at its proximal end and distal third the fibula is subcutaneous and ends as lateral malleolus. No major neurovascular structures runs directly on tibia whereas fibula is closely related to common peroneal nerve and its branches. Four separate muscular compartments exists in the lower leg: Two intermuscular septa, one anterior and one posterior, runs from the deep surface of encircling fascia to the fibula and encloses the peroneal or lateral compartment of leg.

ANTERIOR COMPARTMENT:

It contains the extensor muscles of ankle and foot. It is supplied by anterior tibial artery and deep peroneal nerve. Its medial boundary is formed by the extensor surface of tibia, lateral boundary by extensor surface of fibula and the anterior intermuscular septum. Compartment is covered by the deep fascia of leg.

LATERAL COMPARTMENT:

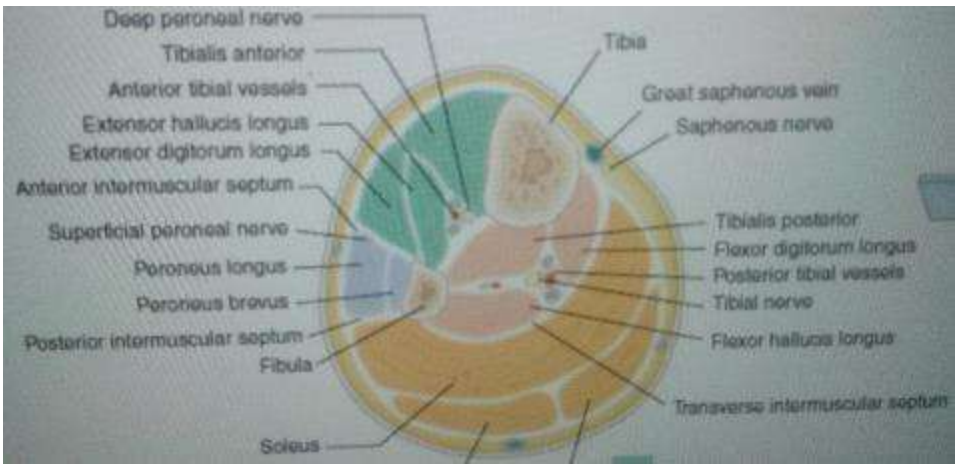
It contains the peroneal muscles which evert the foot. The superficial peroneal nerve supplies this compartment. It is bounded anteriorly by the anterior intermuscular septum, posteriorly by the posterior intermuscular septum and laterally by the fascia over it.

SUPERFICIAL POSTERIOR COMPARTMENT:

This superficial flexor compartment contains three muscles namely gastrocnemius, soleus and plantaris. It is separated from the lateral compartment by posterior intermuscular septum and deep flexor compartment by a fascial layer.

DEEP POSTERIOR COMPARTMENT:

The deep flexor compartment contains three muscles namely tibialis posterior, flexor hallucis longus and flexor digitorum longus. It contains the tibial nerve and posterior tibial artery. It is separated from the superficial flexor compartment by a fascial layer and anterior compartment by the interosseous membrane.



AMPUTATION

The word “amputation” is derived from the latin word Amputare which means “cutting around”. Amputation is defined as the surgical removal of a part or whole of the limb and disarticulation means removal of limb through a joint.

INDICATIONS:

Amputation is considered when the limb is

1. Dead(gangrenous)
2. Dying(grossly ischemic)
3. Dangerous(malignancy)
4. Dud (useless limb) [33]

Trauma is the leading cause for amputations in younger productive age group. Such injuries have a profound effect on their lives. Several studies have suggested guidelines to help in the decision process of “which limbs are salvageable.” [34]

Condition	Indications
Trauma	Road traffic accidents Train traffic accidents Occupational crush injuries
Vascular diseases	Atherosclerosis(eg: diabetes) Gangrene Thromboangitis Obliterans
Neoplastic conditions	Malignant tumors of bone and soft tissues(eg: Osteosarcoma, synovial sarcoma)
Infective conditions	Gas gangrene Actinomycosis
Burns Frostbite	

All compound injuries are classified under GUSTILO-ANDERSON classification

Type 1	Clean wound < 1cm
Type II	Laceration >1 cm long but without extensive soft tissue damage, skin flap, avulsion.
Type IIIa	Open fractures with extensive soft tissue laceration or flap but maintain soft tissue coverage of bone. This includes segmental and severely comminuted fractures even with 1 cm laceration.
IIIb	Open fractures with extensive soft tissue laceration with periosteal stripping and bone exposure. Usually massively contaminated.
IIIc	Open fracture with an arterial injury that requires repair regardless of the size of wound.

For all compound injuries, Gustilo recommended administration of 2 g of third generation cephalosporins on admission and 1 g every 8 hours for 3 days only in types I and II open fractures. In type III open fractures he recommended an aminoglycoside in dosages of 3 to 5 mg/kg daily, adding penicillin, 10 to 12 million U daily, for farm injuries. Gustilo continued double antibiotic therapy for 3 days only and repeated the antibiotic regimen during wound closure, internal fixation, and bone grafting. [34] Most authors agree that Gustilo Anderson type IIIc open tibial fractures, crush injuries with warm ischemic time over 6 hours are absolute indication for amputation[34]

LIMB SALVAGE VS AMPUTATION

To help in the decision making process, scoring indices like predictive salvage index, the limb injury score, the limb salvage index, the mangled extremity syndrome index, the mangled extremity severity score are available. The widely accepted scoring system is Mangled extremity severity score.

Mangled extremity Severity Score (MESS)[34]

Type	Characteristics	Injuries	Points
1	Low energy	Stab wounds, simple closed fractures, small calibre gun shot wounds	1
2	Medium energy	Open or multiple level fractures, dislocation, moderate crush	2
3	High energy	Shotgun blasts, high velocity gun shot wound	3
4	Massive crush	Logging, railroad, oil rig accident	4

Type	Characteristics	Injuries	Points
Shock group			
1	Normotensive	Stable blood pressure (BP) in field and operating room	0
2	Transiently Hypotensive	Unstable BP but responsive to fluids	1
3	Prolonged Hypotension	Systolic Blood pressure <90 mm Hg in field and responsive to iv fluids only in OT	2
Ischemia group			
1	None	Pulsatile limb	0+
2	Mild	Diminished pulses without signs of ischemia	1+
3	Moderate	No pulse on doppler imaging, sluggish capillary refill, paresthesia, diminished motor activity	2+
4	Advanced	Pulseless, cool, paralysed, numb without capillary refill	3+
Age group			
1	<30 yrs		
2	>30-<50 yrs		
3	>50 yrs		

If ischemia time>2 hours: add 2 points

Studies have shown that limbs with a score of 7 to12 ultimately requires amputation, whereas scores of 3 to 6 resulted in viable limbs. Problems with attempt to salvage a severely injured limb may lead to metabolic overload and secondary

organ failure. This is common in patients with multiple injuries and elderly. An Injury Severity Score of greater than 50 is a contraindication to limb salvage. [34]

TYPES OF AMPUTATION:

1.Guillotine amputation:

This is an emergency amputation done as a life saving measure, in cases of gross crush injuries of limb and is gas gangrene. The incision is circular around the limb at the site of bone sectioned and all the tissues are cut at the same level and the wound is left open to provide free drainage.

2.Revision amputation:

This is done as a second stage procedure, following guillotine amputations. Based on stump function it is divided into two types.

A) Definitive end bearing amputation – It is performed when pressure or weight is borne through end of stump. Therefore, the scar must not be terminal and the bone end must be solid.

b) Definitive non-end bearing amputation – Since the weight is not to be taken at the end of stump, scar can be terminal.

3. Primary closure of amputation stump:

Due to high risk of contamination with the perceived risk of clostridial infection and gas gangrene, it is not the preferred technique following trauma, which requires a second wound inspection to assess for signs of ischemia or non-viability of tissue and further debridement should ideally be conducted at 24 to 48 hours post-

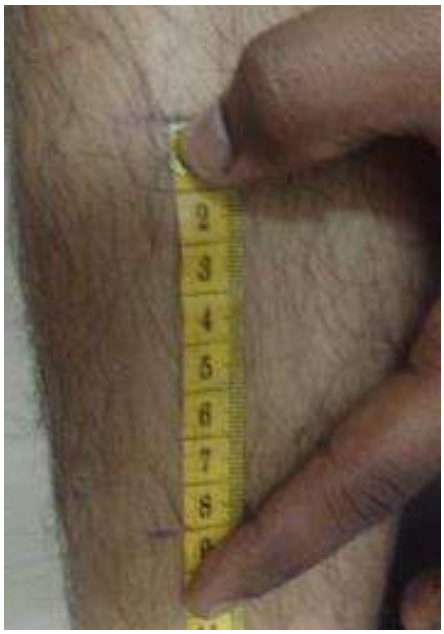
operatively. Primary closure of amputation stump is performed following closed vascular injuries.

PRINCIPLES OF AMPUTATION: [33]

1.Skin flap

Flaps should be thick and should be prevented from further devascularisation by unnecessary dissection. The end of a stump must be covered by a sturdy soft tissue envelope. Atypical flaps are always preferable at a proximal level. Redundant soft tissues or large dog ears are prevented since it poses problem in prosthetic fitting. Scar must never be adherent to underlying bone.

Fashioning of skin flaps



2.Muscle flap

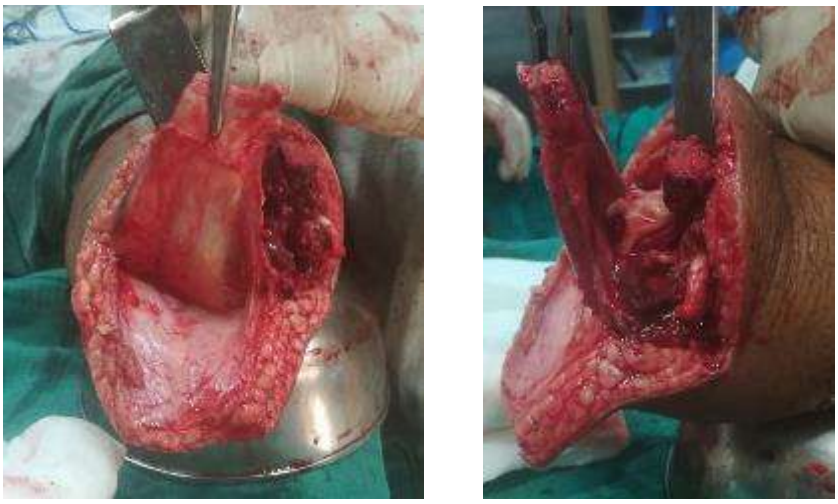
Muscle is divided at least 5cm distal to intended bone section. It can be stabilised by myodesis or myoplasty. Myodesis is suturing of muscle or tendon to bone under physiological tension. It counteracts the antagonist muscles, prevent contractures and maximise residual limb function. However, it is contraindicated in ischemic limbs due to the increased risk of wound breakdown. Myoplasty is suturing muscle to periosteum or to fascia of opposing musculature. If transected muscle is not stabilised properly it undergoes 40-60% atrophy in 2 years duration. Advantages of Myodesis / Myoplasty includes:

a) Shape of stump is good
b) Muscle insulate the cut end of nerve and bone from prosthesis by producing a cushion end.
c) Muscle originating proximally to joint produce better stump mobility and leverage is increased.

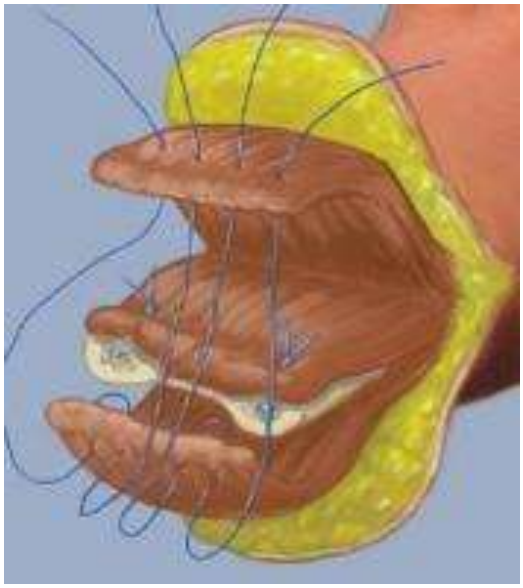
d) Muscle which do not act on the above joint contract isometrically and assist in venous return.

e) Prevent retraction and painful muscle contraction.

f) Phantom pain can be prevented.



Myodesis



Myoplasty

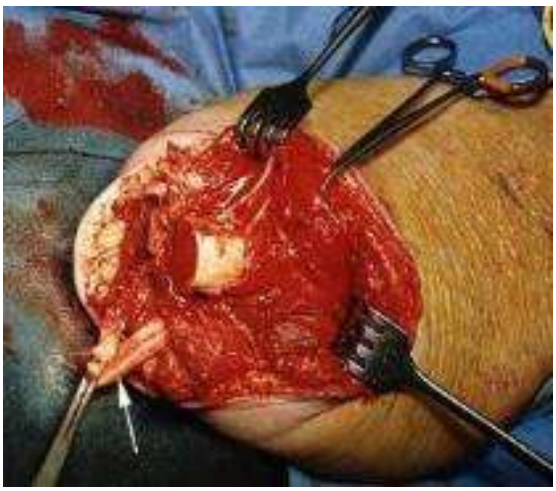
3.Blood Vessels

Major blood vessels should be isolated and separately ligated. Large vessels must be doubly ligated. Haemostasis must be obtained before closure. A drain is kept in most cases for up to 48 hours.

4.Nerves

A neuroma always forms after division and becomes painful if subjected to repeated trauma. Techniques to avoid painful neuroma formation include end-loop anastomosis, perineural closure, Silastic capping, sealing the epineural tube with butyl

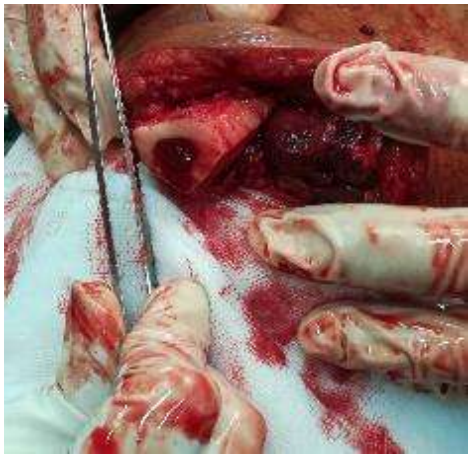
cyanoacrylate, ligation, cauterisation, bury nerve end in muscle or bone. Most commonly practised method is the nerve is isolated, gently pulled distally and cut with sharp knife so that the cut end retracts well proximally.



5.Bone

Excessive periosteal stripping must be avoided since it results in formation of ring sequestra or bony overgrowth. Bony prominences must be either well-padded by soft tissue or should be rasped to form smooth contour. The anteromedial angle beveled to provide a large radius on the anteromedial aspect.

Bevelling of anterior cortex



Rasping to smoothen the anterior cortex

SURGICAL TECHNIQUE

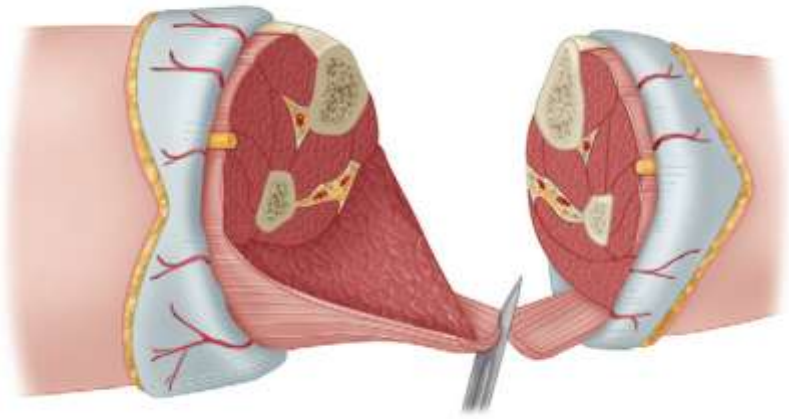
Trans-tibial amputation: [33]

With the patient in supine position, from the antero-medial joint line, measure the desired length of bone and mark it with a pen. Outline equal anterior and posterior skin flaps. The lengths of each flap equals to one half the anteroposterior diameter of leg at the anticipated level of bone section.

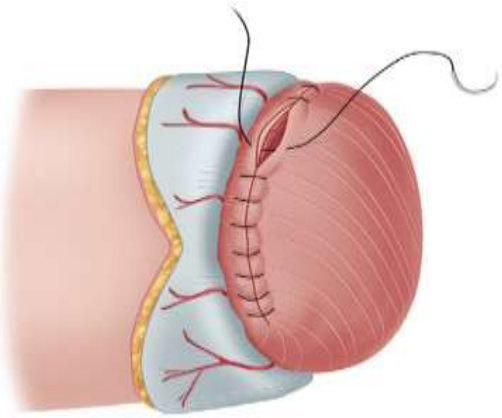
Incise the skin anteromedial / lateral at the intended level of bone section and swing it convexly distal ward and end at a similar position in the opposite side of leg. Similarly, mark the posterior incision. Along the antero-medial aspect, raise a single flap along with the periosteum, till the level of intended bone section. Insert a curved haemostat along lateral aspect of tibia, follow the interosseous membrane and emerge anterior to peroneus brevis muscle. Isolate the superficial peroneal nerve and divide it a at high level so that it retracts well proximal to the end of stump. Divide the anterior compartment muscles 0.6 cm distal to the bone section and divide the anterior tibial vessels and deep peroneal nerve proximal to bone section. Section the tibia

transversely around the fibula 1.2 cm proximally. Grasp the distal end with bone holding forceps and divide the posterior muscle mass 0.6 cm distal to the bone section. Doubly ligate and cut the posterior tibial and peroneal vessels. Create posterior gastrocnemius-soleus flap such that it crosses the tibia till the anterior fascia. Smoothly round the bone ends and cover them with the flap, suturing them to the anterior fascia. Place a suction drain 12 cm proximal to the stump end. An immediate post-operative rigid dressing help to control the oedema and limits knee flexion contracture.

Fashioning of posterior myofascial flap



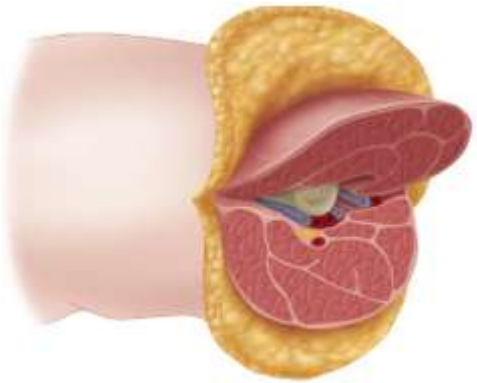
Suturing of posterior myofascial flap to periosteum anteriorly.



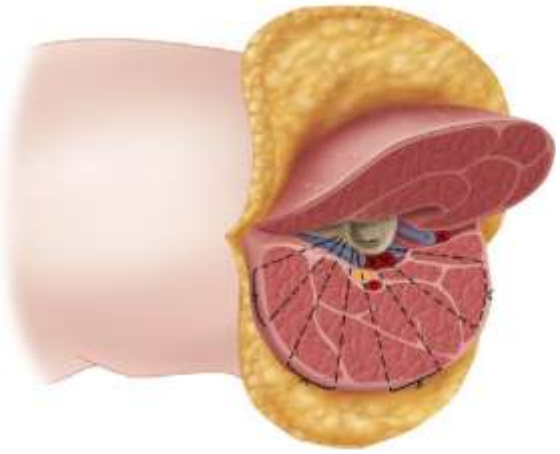
Transfemoral amputation [33]

With the patient in supine position, at the anticipated level of bone section, outline equal anterior and posterior skin flaps, the length of each flap equals to one half the anteroposterior diameter of leg at the anticipated level of bone section. Deepen the skin incision through subcutaneous tissue and deep fascia and reflect the flap proximal to the level of bone section. Divide the quadriceps muscle along with its fascia and reflect it proximal to the level of bone section as a myofascial flap. Identify, ligate and transect the femoral artery and vein in the femoral canal above the level of bone section. Transect the bone and smoothen the edges. Identify and divide the sciatic nerve well proximal to the cut end of bone. Divide the posterior muscle transversely at the level of bone section. Then drill small holes just proximal to the cut end of femur and attach the adductor and hamstring muscle to the bone with non-absorbable sutures under slight tension(myodesis). Bring the quadriceps myofascial flap and suture it to the posterior fascia of the thigh(myoplasty). Bring out the drain 10cm proximal to stump along the lateral aspect of thigh. Approximate the skin edges with interrupted sutures.

Myofascial flap tailored from quadriceps muscle and fascia



Adductor and Hamstring group attached to femur end through holes drilled in bone



Disarticulation of Knee [33]

It results in an excellent end bearing stump. Newer socket designs and prosthetic knee mechanism that provide swing phase control have reduced the patient complaints concern at this level of amputation. A study has showed knee disarticulation is not successful in post-traumatic amputation, presumably because of the lack of viable musculature in the zone of injury. Advantages includes:

- Preservation of large end-bearing surface of distal femur covered by soft tissue and skin that are naturally suited for weight bearing.
- Creation of long lever arm controlled by strong muscles
- Stability of the prosthesis
- In non – ambulatory patients, additional extremity length provides adequate sitting support and balance.

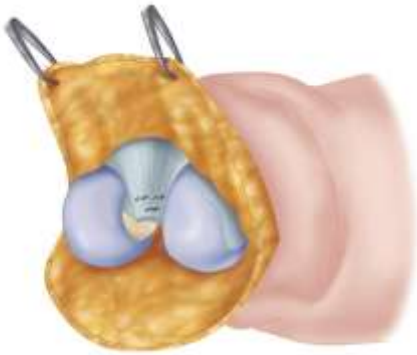
Techniques have been developed to reduce the distal bulk of bone at stump end to allow more cosmetic prosthetic fitting while still retaining the weight bearing, suspension, and rotational control features of stump.

Anteriorly from the inferior pole of patella fashion an anterior flap with length equal to the diameter of knee. Posteriorly, from the popliteal crease, fashion a short posterior flap with the length equal to one half of the diameter of knee. Place the lateral end of flap at lateral end of tibial condyle. Anteriorly, deepen the incision to bone and raise flap from tibia which includes the patellar tendon and pes anserinus. Then, the knee joint is exposed by dissecting the capsule from anterior and lateral margins of tibia, divide the cruciate ligaments and dissect the posterior capsule from tibia. Identify the tibial nerve gently pull it distally and divide so that it retracts well proximal. Identify, doubly ligate and divide the popliteal vessels. Then, divide biceps from the fibula, complete the amputation posteriorly and remove the leg. Do not excise the patella or damage the femoral or patella articular surface. Then suture the patellar tendon to cruciate ligaments and remnants of gastrocnemius muscle to tissues in the intercondylar notch. Drain is placed and approximate the deep fascia and subcutaneous with absorbable sutures and skin with interrupted non-absorbable sutures.

If skin closure is tight or impossible, resect the posterior part of femur condyle rather than risk loss of skin flaps. Even if the wound fails to heal primarily, it usually granulates and heals satisfactorily without additional surgery. Generally, the wound heals quickly and permanent prosthesis can be fitted within 6-8 weeks because shrinkage of stump is not a factor.

Anterior and posterior capsule with cruciate divided

Cruciates along with the patellar tendon attached to intercondylar notch



Features of an ideal stump: [35]

A good stump is necessary for fitting a good prosthesis and better rehabilitation. The characteristics of an ideal stump includes

1. Ideal length
2. Ideal shape
3. Muscular and not flabby
4. Good muscle power

5. No fixed deformity
6. Full and free movements at the joint above
7. Non- adherent incision scar
8. Absence of neuroma
9. Free from infection
10. Bone end well covered with muscle.

Type of stump	Difficulty	Treatment	prevention
Too short	Short leverage and stump slips out of socket	To provide slip socket to prosthesis	Ideal length maintained
Too long	a) wound healing difficult b) stump strikes the socket	Revision amputation	Ideal length maintained
Bulky	Socket fit becomes difficult	Firm stump bandage	Bandaging the stump for proper shape
Flabby	Less muscle power and difficulty to move prosthesis	Exercise for stump	From third day post op start stump exercise
Bony	No soft tissue cover over bone	Adequate soft felt padding within socket	Adequate muscle flap should be left
Deformed (Flexion contracture)	Difficult to fit prosthesis since limb not in alignment.	a) Passive stretch of stump b) active movements c)tendon and bone surgery	-Proper physiotherapy for stump -Avoid pillows to stump -Prone position

Rehabilitation of an amputee [43]

Rehabilitation of lower limb amputees consists of the pre-amputation, postoperative, pre-prosthetic and prosthetic rehabilitation stages, during which an amputee is provided with a prosthetic aiding device. During this period an amputee tries to adapt to the prosthesis and achieve the restoration of ambulation and other locomotive abilities with the aid of a prosthesis. Medical rehabilitation should by all means be accompanied by adequate psychological and social rehabilitation, so as to attain the ultimate goal of rehabilitation, that is, a successful reintegration of an amputee into everyday life almost to the level of pre-amputation daily living as much as possible. Rehabilitation helps to achieve the maximal possible emotional, physical, vocational, social and financial independency of an amputee and maximal efficiency in all aspects of life. One of the factors that enable the successful outcome of limb amputee's rehabilitation is an interdisciplinary, well-coordinated teamwork of physiotherapists, occupational therapists, nurses, a psychologist and a social worker. A person, following amputation experiences not only the loss of an anatomic part of the body, but also functional losses, changes in coordination, body weight distribution, balance impairments and proprioception.

AGENDA OF REHABILITATION

1. Pre-operative rehabilitation stage
2. Amputation surgery
3. Acute post – amputation care
4. Preprosthetic training
5. Prosthetic fitting and training

6. Reintegration into community
7. Vocational rehabilitation
8. Long term follow-up

PRE -OPERATIVE REHABILITATION STAGE:

It is the time-period before an amputation**.** The goal is to prepare the patient and the family members for the amputation surgery and to educate them about the rehabilitation options. The patient and the family members must be informed about the reason for amputation and convinced that amputation is the only therapeutic option left. The patient is prepared for the amputation based on the assessment of an interdisciplinary team. Within this period, the state of the leg to be amputated, state of the contralateral leg, should be evaluated. The treatment should be focused on adequate pain management by administration of effective painkillers (commonly mild or stronger opioid drugs) and with the addition of antidepressants and sedatives if necessary. The surgeon informs the patient and the family about the surgery, the foreseen level of amputation, the postoperative care, prosthetic aid provision and prosthetic rehabilitation and finally an informed consent from patient is obtained. In the pre-amputation stage, a kinesitherapy should be started by a physiotherapist. Kinesitherapy comprises of in-bed exercises involving healthy limbs and the trunk, as well as breathing exercises. Preferably, the patient should learn aided ambulation (with crutches or walkers), to prevent overloading the normal limb. The patient and the family members should be provided with psychological support. The patient is introduced to successfully rehabilitated limb amputees. It also helps the patient to

prepare physically and mentally for amputation as well as for coping up with the post amputation period.

POST – OPERATIVE PERIOD:

This period is considered as the healing and protective phase. The goals of post-operative care include promotion of wound healing, pain control for conditions such as phantom limb sensation/pain, volume control, functional mobility, continued emotional support, education. Generally, inpatient stay ranges from 5 days to 2 weeks. Following amputation, a multidisciplinary team consisting of surgeon, physical therapist, an occupational therapist, psychologist and a social worker for post-operative care is required.

After surgery, post op care includes antibiotics, deep vein thrombosis prophylaxis and pulmonary hygiene. Pain management is by intravenous narcotics ,which is then converted to oral analgesics and then gradually weaned off as tolerated.

1.Stump care

Care for stump is very important from the time of amputation until definite prosthesis is fitted, since a strong and functional amputation stump is capable of maximum prosthetic use. Now-a-days rigid dressing consisting of plaster of paris applied over stump is preferred over soft dressing. Advantages of rigid dressing includes protection of wound from bed trauma, edema prevention at surgical site, enhanced wound healing, allows early maturation of stump, decreases post-operative pain, allowing earlier mobilisation from bed to chair and ambulation with support. The physiological benefits of upright posture to respiratory, cardiovascular, urinary, and

gastrointestinal systems are easily recognisable. Finally, earlier definitive prosthetic fitting is possible and a higher percentage of patients are successfully rehabilitated.

If weight bearing ambulation in immediate post op period is anticipated, true prosthetic cast is applied preferably by a certified prosthetist with appropriate stump socks, contoured felt padding over bony prominences, and special suspension techniques.

Stump Care

- Stump drainage and removal of drain on time
- Stump splinting
- Stump bandaging with maximal pressure terminally and minimal pressure proximally prevents blood loss and terminal edema, reduces phantom sensation and produces good shape.
- Stump exercises started early.
- Stump hygiene and intermittent exposure to air prevents skin diseases.

2.POSITIONING

Proper positioning in post-op period is critical initially, as pain may result in a protective flexion withdrawal pattern without the sensory feedback of weight bearing activities. The patient is cautioned against leaving the stump in dependent position.

The frequent contracture seen in trans-tibial amputees is a knee flexion contracture, which can be prevented by donning a knee immobilizer in the immediate post-op. It also prevents trauma to the residual limb.

Frequent contractures seen in trans-femoral amputees include hip flexion, external rotation and abduction. A pillow placed laterally alongside the residual limb will facilitate neutral position. Frequent prone positioning for trans-tibial and trans-femoral amputees is encouraged in the early acute phase.

3.EXERCISE

Early mobility has been shown to improve functional outcomes, promote independence, decrease morbidity and reduce length of stay for individuals with lower extremity amputation. Muscle strength is lost faster than that gained with strengthening exercises. Lower extremity amputees must maximize strengthening potential as they lack the ankle strategies and have impaired hip strategies secondary to the lack of somatosensory input and must depend on intact vision and lumbo-pelvic stabilization.

Patients should be mobilised from bed to chair on the first post-operative day. Exercises consists of muscle-setting exercises followed by exercises to mobilise the joints. Within the first few days, patients should be ambulated using parallel bars, followed by walker/crutches when they can control the limb. The optimal time to begin prosthetic ambulation with protected weight bearing, depends on multiple factors like age, strength, patient ability to protect the stump from injury as a result of excessive weight bearing.

The gold standard exercise for both trans-femoral and trans tibial amputees is lying prone, which promotes extension and combats hip flexion contracture acquired from prolonged sitting on wheel chair. Patients should be able to advance to alternate

arm/ leg lifts and progress to activities on elbows. Pillows / rolled towels can be used for resisted hip / knee extension exercises.

Core strengthening (lumbo-pelvic-hip complex),should be initiated by having the patient contract the lower abdomen achieving neutral spine. Adequate core strengthening provides a base for upper and lower extremity activities and also prevents chronic low back pain and gait dysfunction with later prosthetic training.

All of these pre-prosthetic exercises can be performed in the home care setting and repetition and sets can be increased according to the frequency, intensity and time(FIT) principle and patient tolerance. The goal is to provide a basic functional exercise regimen that can be performed independently and which allows to progress to phase II rehabilitation.

4.WOUND CARE

The wound must be inspected every 7 to 10 days after removing the rigid dressing. The cast must be changed weekly, until wound heals. After healing, the rigid dressing can be removed and an elastic stump shrinker can be used. Rigid dressing is continued until volume appears unchanged from previous week. As stump shrinkage occurs, gentle compression of stump is maintained by applying additional stump socket before donning the plastic socket.

A patient with traumatic amputation through the zone of injury or a patient with amputation secondary to ischemia should wait until wound healing occurs and then gradually be started on weight bearing. If the wound is progressing well, weight bearing can progress in 11.33 kg increments each week.

PRE-PROSTHETIC PHASE:

It is the preparatory phase, intervening between wound healing and prosthetic device provision. Patient can be rehabilitated at his house, nursing home, hospital or rehabilitation centre. This period is useful for preparing the residual limb for prosthesis and conditioning the patient for the expected strain during prosthetic rehabilitation with physical and kinesitherapy. It also aims for the patient to attain independent aided mobility with walker, wheelchair or crutches as well as to perform day-to-day activities via occupational therapy. The patient is taught to take care of the residual limb and to identify complications. Kinesitherapy for above knee amputees aims at strengthening gluteal muscles while in below knee amputees it aims to strengthen knee extensors. Ultimate aim of kinesitherapy is to gain adequate mobility of the existing joint and to prevent contractures of the opposite limb. Rehabilitation goals are set and must be monitored at regular intervals.

Goals are:

• Pain control, maintenance of range of motion and promotion of wound healing.

• General endurance and strengthening exercises should be implemented and exercises should stabilize the proximal muscles and prevent joint contractures.

• Strengthening of upper limb musculature is essential for wheel chair propulsion, transfers and ambulation with crutches or a walker.

• Removable rigid dressing or elastic compressive dressing are used to control pain and residual limb maturation.

• Skin desensitization program that includes gentle tapping, tissue massaging, scar mobilization and lubrication are required.

• Modified stationary bicycle ergometer or universal below knee tricycle attachment or versa climber are used to assist in strengthening and improve endurance in lower limb amputation.

• The normal limb must be evaluated, as to range of motion, strength, sensations, coordination, skin integrity, vascularity and deformities.

• Cardiac and Pulmonary status is evaluated by means of clinical parameters such as heart rate, blood pressure and respiratory rate.

• Nutritional, cognitive and psychological evaluation are also important.

• Presence of comorbidities such as diabetic retinopathy and degenerative joint disease, neuropathy, poly neuropathies also influences rehabilitation outcomes.

• Sitting balance, bed mobility and transfers are facilitated by strong, flexible back and abdominal rotators, flexors and extensor and hip extensors.

• Contractures if present are treated by heating modalities, prolonged passive stretch, spring loaded orthosis, serial casting, nerve blocks or soft tissue surgery.

• Ambulation training without prosthesis is important.

- First trained with parallel bars.
- Standing balance on both legs is taught
- Taking body weights on both legs alternatively
- With bilateral hand support, coordinated stepping is taught
- Next, it is progressed to single hand support
- Sitting to standing and vice versa is taught.

- Turning, side walking and climbing is taught.

Patient is taught balance and equilibrium during all the above activities. Once the patient has mastered with parallel bars, he is made to walk on footmarks over floor in front of a mirror and may be advanced to a walker and then crutch walking. Exercise programme for amputees is focused on flexibility, muscle strength, cardiovascular training, and balance.

PROSTHETIC FITTING AND REHABILITATION

Rapid prosthetic rehabilitation of multiple limb amputees ensures best results in returning to an active independent lifestyle. Contemporary prosthetic fitting of the bilateral lower limb amputee can be categorized into

i) Immediate post surgical prosthetic fitting.

ii) Early post surgical prosthetic fitting

iii) Preparatory prosthetic fitting and

iv) Definitive prosthetic fitting

i) Immediate post – surgical prosthetic fitting (IPPF)

After conventional amputation, stump bandage is applied for a period of 2 months to reduce stump edema and to aid in the shrinkage of the stump, and in this period, patient ambulates using crutches or a walker. During this period, both the visually recorded loss of limb combined with physical disability to ambulate affects the patient psychologically.

IPPF technique consists of a jig, that has a complicated construct of a metal socket attachment strips attached to metal platform, quick disconnect unit, antero-posterior and medio-lateral / varus-valgus sliding unit with antero-posterior angulation

adjustments. The major disadvantage is length cannot be adjusted and tubular shank is cut to required size, prior to fitting. However, this procedure is not followed widely due to increased time consumption in operating room, requirement of prosthetist help and difficulty in procuring prosthetic jig which is interposed between plastic socket and foot piece.

Later an indigenous version with an adjustable shank was innovated with available material at a low cost. This consists of two aluminium tubes which can telescope into each other. The proximal end of proximal tube is radially divided to a length of 6 inches to form 4 socket attachment strips. A circular aluminium disk rivetted at the base of these strips form the socket resting platform. The distal tube is fixed to a Jaipur foot by means of a nut and bolt. Since the tubes can telescope into each other, they can be fixed to required length by means of two horizontal bolts. Advantages of two shank pieces are

(1) It acts as quick disconnect system and the foot piece can be removed whenever required.

(2) Length of shank is adjustable which is not present in the sophisticated version.

IPPF APPLICATION TECHNIQUE:

Under anaesthesia, following wound closure a sterile stockinet with one end closed is applied over the stump. Felt pads are kept over the stockinette to protect the bony prominences. Gauze pieces are placed over stump end and further covered by sponge rubber cup. An above Knee POP cast is applied over the sponge rubber cup (plaster socket) to form a rigid dressing. The suspension straps are also incorporated

into the plaster cast. The proximal half of the shank is secured to plaster socket using POP, and care is taken to fix the axis of shank, half an inch medial to axis of socket to compensate for the valgus position of proximal tibia. Finally, the distal shank with foot piece is fixed after the length is adjusted.

Sponge rubber cup acts as a rigid dressing during weight bearing when compressed by POP cast and promotes distribution of pressure over stump during weight bearing. The appropriate terminal pressure provided by the rigid dressing restricts stump edema, which helps in wound healing, and maturation of stump with favourable stump shaping.

POST OPERATIVE MANAGEMENT:

24 hrs: Suction drain removed and stands by the side of bed.

48 hrs: Walks with walker bears about 3 kg weight

3-8 days: Parallel bar walking – weight bearing increased to 20 Kg

14 days – POP cast removed, sutures removed and temporary prosthesis reapplied immediately over POP cast and continues to walk.

30 days – Definitive prosthesis is given.

Components of IPPF

1- Flexible socket attachment strap

2- Socket resting platform

3,4- Telescoping tubes of shank forming quick disconnect system

5- Horizontal bolts for disconnection

6- Wooden plug in tube

7- Nut and bolt to fix Jaipur foot to shank.

ADVANTAGES:

1. Minimises pain and helps in wound healing and maturation
2. Rigid dressing permits early upright and bipedal stance and gait with awareness of pressure and tension forces transmitted through prosthesis to body, allows proprioceptive inputs.
3. Psychological uplift.

ii) Early Post – Surgical Prosthetic fitting

Frequent cast changes may be indicated when there is considerable evidence of edema at the time of initial application of the cast socket. If a cast socket inadvertently comes off the limb, it should not be pushed back on. A new socket must be applied without delay. Removable cast sockets have been unsuccessful.

At regular intervals full cast should be changed between 7 and 10 days, unless wound problems require more frequent attention. Soft compression dressings supplemented by an elastic bandage or shrinker sock are less effective in achieving rapid wound healing.

iii) Preparatory Prosthetic fitting

It is also referred to as intermediate or training prostheses. They are useful if the volume of residual limb is expected to decrease rapidly in the near future or if a gradual reduction of joint contractures will require repeated prosthetic realignment. It is useful to evaluate a patient's potential to safely ambulate or to demonstrate to the patient ,the energy and skill requirements associated with the use of prostheses. The component choice is carefully prescribed in consideration of the particular patient's needs. It is frequently prudent to utilize definitive foot-shin-knee components for the preparatory prosthesis to carry them over into the definitive device. Maturation of the residual limb by comfortably increasing weight bearing and initial gait training should predominate the preparatory prosthetic phase.

iv) Definitive prosthetic fitting

Vital points before prosthetic application:

-Check the joint alignment and its movements

-Socks should be pulled up and fastened firmly

-Prosthesis must be applied in functional position

Lower limb prosthesis is applied in standing with 2 inches apart in parallel bars

-Check anatomical alignment in respect to normal limbs

-Check the axis of weight bearing and prosthetic joint

-Check overall fitting of socket and suspension

-Check the foot

• After the patient receives prosthesis, frequent monitoring of the skin allows for prompt corrections of socket-fit problems and prevents skin break down.

• Walking programme should start conservatively and progress gradually to 30- 40 minutes per session.

• Balance training / co-ordination is also essential. Gait training includes weight bearing, weight transfer, stepping training, walking with or without assistive aids, stair climbing

• Cleaning and maintaining of prosthesis is important.

Improved biomechanical fitting principles and static and dynamic test socket procedures combined with flexible socket construction further enhance patient comfort and acceptance.

Cosmesis, durability and final gait training become important considerations in the definitive prosthetic phase.

COMMUNITY REINTEGRATION

Day rehabilitation program is one, where the patient participates in rehabilitation for 3 hours a day, 5 days a week, or 6 hours a day, 2 to3 days a week. This allows them to return to a part-time modified work, sports and social activities. The aim of rehabilitation is to achieve optimal independence in mobility and self-care activities and to overcome physical, psychological, social and vocational problems. Tailor – made programmes for each person addressing their specific needs should be looked into. Family's acceptance to change and willingness to modify the home environment to suit the specific needs of the amputee and the patient's ability to manage the mobility aids such as a wheel chair or prostheses needs to be addressed prior to discharge.

For the educational age group, focus should be on strengthening to face systemic challenges and environmental barriers. For the employable group, vocational guidance and counselling followed by vocational evaluation, job evaluation with workplace adjustments and suitable job placements are to be incorporated into the rehabilitation plan. If the person is a home maker, the rehabilitation would be to focus

on how she can manage the affairs of the home such as child-rearing, cooking and other household activities.

The steps to go through this treacherous path of equipping the person to be self-reliant are:

i) Improve the support system

ii) Get involved in physical activity (exercise and self-care)

iii)Join a self – help group

iv) To obtain professional guidance and counselling

v) To rebuild the sense of well – being, purpose and to achieve dignity and worth

vi) community re-integration

LONG TERM FOLLOW UP

Regular follow ups are required for successful rehabilitation. The family members are also involved, depending upon the nature of the problems.

Complications [44]

Immediate post-op status, early recognition of infection, sepsis, deep venous thrombosis, pulmonary embolism could not only affect overall prognosis, but rehab potential as well.

Other long-term complications include,

a) Pain

Phantom complex includes

Phantom limb pain – Painful sensations referred to the absent limb. Usually the onset of pain is early, occurring within few a few days of amputation, and is localised to the distal part of the missing limb, and is intermittent in nature. Both the frequency and duration of pain attacks are significantly decreased during the course of follow up. The median phantom pain score decreases from moderate to minimal in a follow up of 5 years post operatively. In traumatic amputees, phantom pain was related to pre-amputation pain immediately after the amputation, due to cortical pain memory.

Mechanism - A series of mechanisms are involved in generating phantom pain and these include elements in the periphery, spinal cord and brain. The involvement of cortical brain structures is responsible for complex and vivid sensation that characterizes certain phantom pain sensations.

Medical treatment – Tricyclic antidepressant(TCA) and sodium channel blockers are the treatment of choice for neuropathic pain. The TCA drug doxepin was reported to be effective in treatment of phantom pain.

Non-medical treatment – Medical treatment can be combined with non-invasive techniques such as Transcutaneous electrical nerve stimulation(TENS), and vibration therapy.

Surgical treatment – Stump revision or neurectomy may be effective in local stump pathology.

Phantom limb sensation - Any sensation in the absent limb, except pain. Immediately after amputation, the phantom limb often resembles the pre-amputation

limb in shape, length and volume and often includes feelings of posture and movement. In some patients, telescoping phenomenon occurs when distal part of phantom limb approaches the residual limb and in the end, it may be experienced in the stump. Overtime, phantom sensation fades.

Stump pain/ Residual limb pain

Pain is localised in the stump. It is common in the early post-op period and subsides with healing. If it persists, it signifies pathology such as infection, bone spur, neuromas, adherent and wrinkled scars. Might also be due to hyperalgesia or allodynia. The main problem with persistent stump pain is that it interferes with prosthetic use and rehabilitation.

Contralateral joint pain - It is thought to arise from a combination of gait abnormalities and increased physiological loads on intact joints. It is uncommon in below knee amputees.

Back pain – Thought to occur as a result of altered gait pattern. Found to be more in above knee than below knee amputation.

b) Psychological responses

Post traumatic stress disorder(PTSD) unique to trauma exposure, is characterised by symptoms of avoidance, re-experiencing the events pertaining to the trauma and hyperarousal. Anxiety, depression and substance abuse often co-exists.

c) Cardiovascular disability

Patients with traumatic leg amputation have increased risk of cardiovascular morbidity and mortality. Research has shown that traumatic leg amputees have higher insulin resistance and blood coagulability compared with healthy subjects. Studies have shown unilateral above knee amputees have greater risk for ischemic heart disease (relative risk 3.3 versus healthy controls) and abdominal aortic aneurysm (relative risk 5.1 versus that in veterans without amputation).

d) Reduced physical function

Traumatic leg amputations affect physical function markedly. Residual limb length and the quality of soft tissue coverage are the important variables in determining physical outcome. Objective measures like walking speed, gait efficiency and energy for mobilisation have shown better results in trans-tibial amputees than in more proximal level amputees. Also patient mobility of less than 500 metres indicates difficulty in activities of daily living.

PROSTHESIS [45]

Prosthesis is defined as a replacement or substitution of the missed or diseased part of the body both in appearance and function. A sequence of careful fittings and follow-up are necessary to achieve optional fit and alignment. Repairs and adjustments should be done as warranted by the individual's activity level and lifestyle.

Aims of prosthetic fitting includes:

- To substitute for a lost part
- To restore a lost function

- In lower limbs, it provides comfortable ambulation with minimal expenditure of energy.

PROSTHESIS FOR LOWER LIMBS

Longer stump is prosthetically superior to shorter one because it provides

- Longer lever arm
- More sensory feedback
- Greater area for distribution of pressure forces

CLASSIFICATION BASED ON PERIOD OF USE:

1.Temporary prosthesis: It is used following an amputation till the patient is fitted with a permanent prosthesis.

2.Permanent prosthesis: This is fitted following final clinical assessment with accurate measurements of stump.

COMPONENTS OF A PROSTHESIS:

Socket: Provides a receptive area for the stump and helps in weight bearing and transmission of forces, provides support and contoured sockets have close fit to bone, muscle and soft tissue.

Suspension: Helps to attach the socket to body.

Types - Sleeve, Belt, strap, cuff

Joints: These are artificial mechanical joints which replace the original joints.

Types: Manually operated/ Semi-automatic / automatic

Shank/pylon – Helps to connect socket to foot ankle assembly. Allows axial rotation and absorbs, stores, and releases energy.

Exoskeleton - soft foam contoured to match other limb with hard outer shell.

Endoskeleton – Internal metal frame with cosmetic soft covering.

Base/ Ankle foot assembly : This part rests on the floor and is designed to provide support during standing/walking and shock absorption

Uniaxial foot – permits only dorsiflexion and plantar flexion

Double axial foot – Permits inversion and eversion in addition to dorsiflexion and plantar flexion

Rigid pelvic band – Permits only hip flexion and extension

Double swivel joint – Permits all movements of hip

PROSTHESIS FOR TRANSFEMORAL AMPUTEES:

(a)Suction socketed limb – Suited for cylindrical stumps and useful in young adults. It snugly fits with the stump and has a two way valve mechanism to maintain negative pressure.

Advantages :

- Skin infection is less common
- Free from harness
- Greater feel of close contact between the prosthesis and stump
- Stump socks are not necessary

(b)Non – suction socketed limb – Pelvic bands or harness is used instead of negative pressure. Advantages include :

- Easy to wear
- No perspiration

- Stump circumference remains unaltered.

Socket – Quadrilateral H socket

Suspension – Double swivel pelvic band / Rigid pelvic band/ Suction socket valve

Knee – Modular prosthesis - hand operated or semi automatic locking

Feet – Solid ankle cushion heel or uniaxial foot

PROSTHESIS FOR THROUGH KNEE AMPUTATION

Socket – Thigh corset

Suspension – rigid pelvic band or waist band or shoulder suspension band

Knee – Uniaxial joint manual or automatic locking

Feet – Solid ankle cushion heel or uniaxial foot

PROSTHESIS FOR BELOW KNEE AMPUTATION:

(1) Conventional prosthesis

Socket – Extend 3 cm above the lower pole of patella with a metal or polyester proximal weight bearing socket.

Suspension – Rigid pelvic band. If required, shoulder strap or waist belt is used.

Knee joint – Uniaxial

Feet – Uniaxial

INDICATIONS

1.Heavy manual labourers

2.Patellar defects

3.Fixed flexion deformity of knee >25 degrees

4.Unstable knee

5.Very short stump

ADVANTAGES:

1. Thigh corset supports some weight bearing
2. Prevents hyperextension at the knee
3. Provides medio-lateral stability

(2) Patellar tendon bearing (PTB) prosthesis

Socket – Soft inner socket with hard covering

Suspension – Elastic stocking, suspension, supracondylar cuff

Feet – Uniaxial or multiaxial solid ankle cushion heel.

Advantages:

1.Permits normal gait

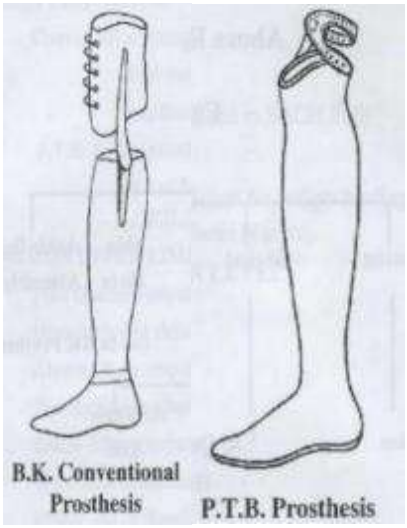
2.Permits early rehabilitation

3.Convenient for patients with long stump

4. Total contact design

-Improve circulation and prevents edema

- Better proprioception



COMPLICATIONS IN PROSTHESIS USE:

1.Choke syndrome : It is caused by obstructed venous outflow due to socket with tight fit.

Acute phase: red, indurated skin with orange peel appearance.

Chronic phase: hemosiderin deposits and venous stasis ulcer

2.Skin problems:

a) Contact dermatitis

- It is caused by liner, socks or suspension mechanism

b) Cysts and excessive sweating

- It is a sign of excessive shear force and improperly fitted components

3.Ineffective suspension system

4.Poor socket fit

5.Stump volume changes

6.Foot alignment abnormalities

Factors affecting outcome following traumatic limb amputations [46]

1.Pain

Chronic pain is a significant cause of disability and worsens the functional, vocational and psychiatric outcome of amputees following trauma related amputation. It is important to differentiate the cause of chronic pain

Phantom pain – It is a form of neuropathic pain, experienced by 50-80% of amputees. It is associated with the magnitude of pre-amputation pain due to the development of cortical pain memory.

Residual limb pain – It is present immediately after amputation but resolves with wound healing. However it persists in 55-76 % of amputees. Residual limb pain is twice as common in traumatic amputee patients compared to that of non-trauma limb amputees.

Back pain – It is experienced in 52-81% of traumatic amputees which is a comparatively higher incidence than that which occurs in the general population. Back pain is more common in above knee than below knee patients. It is attributed to myofascial changes following amputation and altered gait pattern to accommodate the prosthesis.

Contralateral joint pain – Traumatic amputees have two times more risk than normal population to develop knee pain in the intact limb. That is approximately 50-63% following trans femoral amputation and 36-41% after trans-tibial amputation. It might be due to the altered gait abnormalities and increased physiological load on the intact joint.

2. Psychological responses

Depression and anxiety occurs in 25% of patients and substance abuse in 6% of patients. Post-traumatic stress disorder characterised by symptoms of avoidance, re-experiencing and hyperarousal is unique to trauma exposure and experienced by two-thirds of patients. Trans femoral amputee's self-reported mental and emotional health outcomes were significantly worse than that of the control group.

3. Reduced physical function

Variables that determine the functional outcome includes residual limb length and quality of soft tissue coverage. The disability increases with higher level of amputation. Objective measures on gait efficiency, walking speed, energy requirement for mobilisation as well as self-reported quality of life measures shows better outcome in in trans-tibial amputees than proximal level.

The quality of soft tissue envelope of residual limb is important as this provides comfort and durability needed for prosthetic tolerance and weight bearing. Through knee amputation is preferable to above knee amputation due to natural weight bearing capacity of femoral condyles with the retained muscle attachments.

4. Impact on employment

Return to work following traumatic leg amputation depends on various factors like age, preinjury vocational ability, level of amputation, residual limb health, associated injuries, national disability system and social support. In USA, approximately 52-70 percent of lower limb amputees return to work whereas in UK and parts of Europe more than 95% of amputees return to work. In Indian population, no literature review is available regarding return to work in traumatic lower limb amputees.

A systematic review, average rehabilitation time before returning to work is approximately one year, most of the amputees return to less physically demanding employment and a large proportion of amputees remain in long term employment.

5. Cardiovascular disability

Traumatic leg amputees have increases risk of cardiovascular morbidity and mortality. Unilateral above knee amputees have 3.3 times more relative risk than healthy control for ischemic heart disease and 2.2 times more risk for abdominal aortic aneurysm than healthy individuals.

Long term follow-up shows modifiable risk factors as cause of cardio vascular problems which includes, physical inactivity, PTSD and substance abuse. Research has revealed amputees have higher insulin resistance and blood coagulability compared with healthy subjects.

MATERIALS AND METHODS

Place of study : Institute of Orthopaedics and Traumatology, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai.

Type of study : Prospective and retrospective study

Sample size : 47

Period of study : 2016-2017

INCLUSION CRITERIA

1. Traumatic amputations
2. Gustilo – Anderson grade III b and c compound injuries leading to amputations.
3. Crush injury

EXCLUSION CRITERIA

1. Distal to ankle joint / Hip disarticulation
2. Age < 10 years
3. Other indications of amputations like peripheral vascular disease, Diabetes Mellitus, wet Gangrene

All trauma patients received in zero delay ward were resuscitated under ATLS protocol. Patient vitals which includes pulse, blood pressure, respiratory rate and

oxygen saturation are recorded and two large-bore cannulae are inserted and venous sample for blood grouping and typing, cross match, complete blood count, renal and liver function tests and viral markers Hbsag, HIV, HCV are sent . Primary survey includes assessment of

A- airway maintenance with cervical spine protection.

B- Breathing and ventilation

C- Circulation with Hemorrhage control

D- Disability (Neurological examination)

E- Exposure

A- Airway maintenance with cervical spine protection

If airway compromise is present it is initially addressed by airway positioning, suction, and use of adjuncts like oropharyngeal airway. Despite these measures, if patients have persistent airway obstruction or inadequate oxygenation or unable to protect airway due to reduced conscious level, these patients are given early definitive airway management using cuffed endotracheal tube. Further injury to cervical spine is prevented by semi-rigid cervical collar, blocks and tape.

B- Breathing and ventilation.

Once airway is secured, high flow oxygen is delivered by face mask or endotracheal tube and the patient is assessed for injuries to lung, chest wall and diaphragm. Rapid evaluation of pneumothorax, hemothorax, flail chest and cardiac tamponade is done .

C - Circulation and Hemorrhage control

Patients with signs of hemorrhagic shock, immediate resuscitation with crystalloid is started initially and later cross matched blood is transfused. Patient is assessed for hidden bleeding in thorax, abdomen and pelvic cavity and fractured long bones.

D - Disability (Neurologic evaluation)

Neurologic evaluation is made with Glasgow coma scale.

E-Exposure

Patient is undressed to identify clinical signs of hidden injuries.

SECONDARY SURVEY

During secondary survey history is obtained and complete head to toe examination is done and appropriate radiographs are requested depending on the clinical findings along with the trauma series X-rays consisting of X-ray cervical spine antero-posterior / lateral, X-ray chest PA view and X-ray Pelvis with both hips – AP view are taken.

For compound injuries, patients are prophylactically given Inj. Tetanus immunoglobulin 500 IU intramuscular stat dose and third generation cephalosporin Inj. Cefotaxime 1g iv and aminoglycoside 500 mg iv stat dose are administered.

All compound injuries are classified under Gustilo–Anderson classification.

Gustilo-Anderson Grade IIIc compound fractures and mangled extremities with MESS score >7, after obtaining vascular surgeon and plastic surgeon opinion are taken up for amputation. In Gustilo-Anderson Grade IIIb compound fractures initially managed with external fixator, serial wound dressing was done and followed. If the wound worsens and remains unsatisfactory after repeated debridement after attaining plastic and vascular opinion, patient is taken up for amputation surgery. Since the wound is contaminated and results in infection and sepsis, initially guillotine amputation is performed, followed by daily dressing and antibiotics. If wound settles and covered by healthy granulation tissue, patient is taken up for revision amputation or split thickness skin graft. Following initial amputation, if wound remains infected, patient is taken up for debridement and wound swab is taken for culture sensitivity and appropriate antibiotics is administered. Post revision amputation, slab is applied and wound care is given and antibiotic post-operatively for three days.

After suture removal, patient is referred to Government Institute of Rehabilitation centre KK nagar attached to Rajiv Gandhi government general hospital for rehabilitation. After receiving prosthesis patient is given gait training.

Post-operatively after 3 months patients were interviewed and questionnaire was filled. Survey items includes standardised SF-12 score, patient morbidity, prosthetic use, mobility, employment.

Retrospective patients data were obtained from registers of trauma ward and general wards and IOTRA (Institute of Orthopaedics and Traumatology Research Analysis section). Patient demographics (Name, age/sex, address with contact number with diagnosis and surgery done) were obtained.

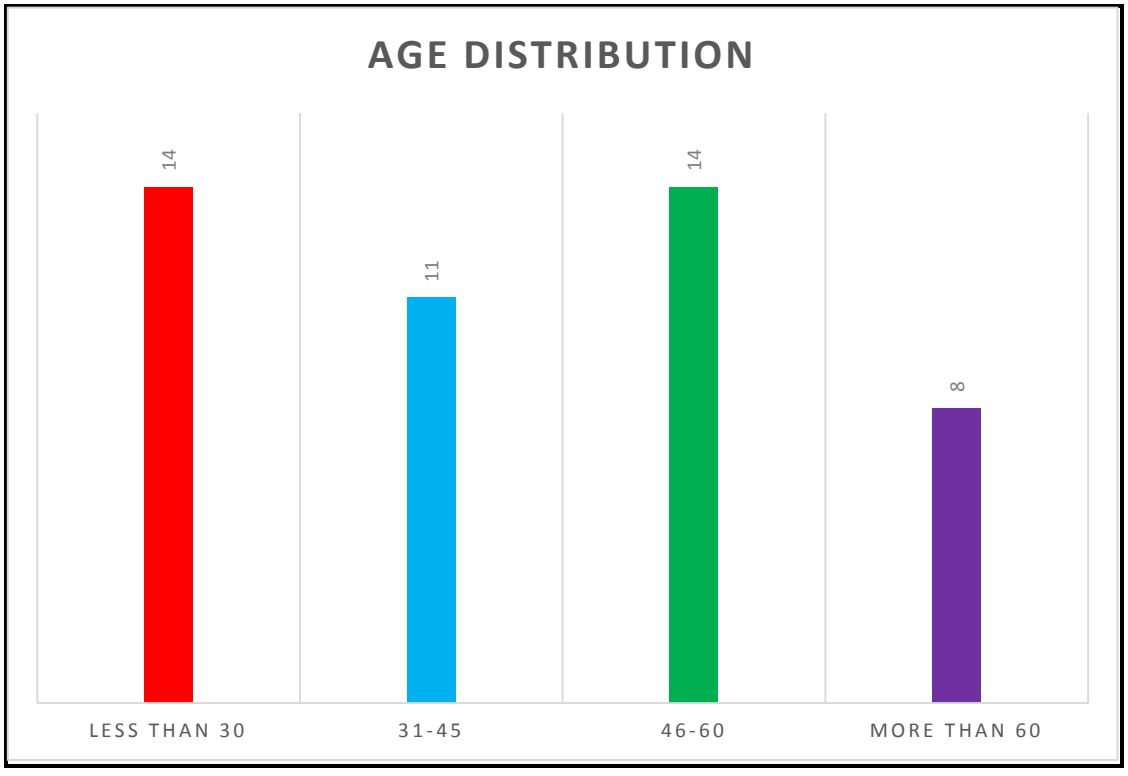
The questionnaire includes SF-12 score, a measure of health-related quality of life. It allows calculation of overall and separate physical and mental component score, each expressed as a value between 0 and 100 with a high score representing a better quality of life.

RESULTS

(1) Age Distribution

Age (IN YEARS)	No. of patients	Percentage
Less than 30	14	30%
31-45	11	23.50%
46-60	14	30%
More than 60	8	16.50%

In our study most common age group is <30 years and 46-60 years. The mean age in our study is 44.08 years and the range is 13-83 years.

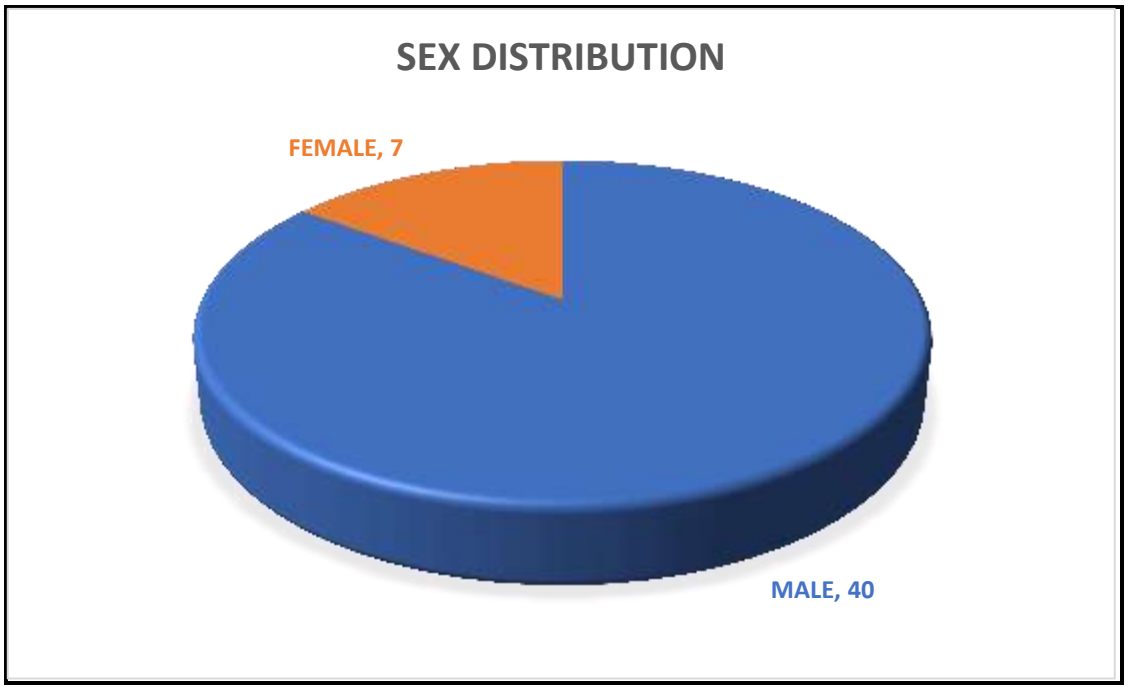


(2) Sex Distribution

Male: Female ratio – 5.7:1

Sex	No of patients	Percentage
Male	40	85%
Female	7	15%

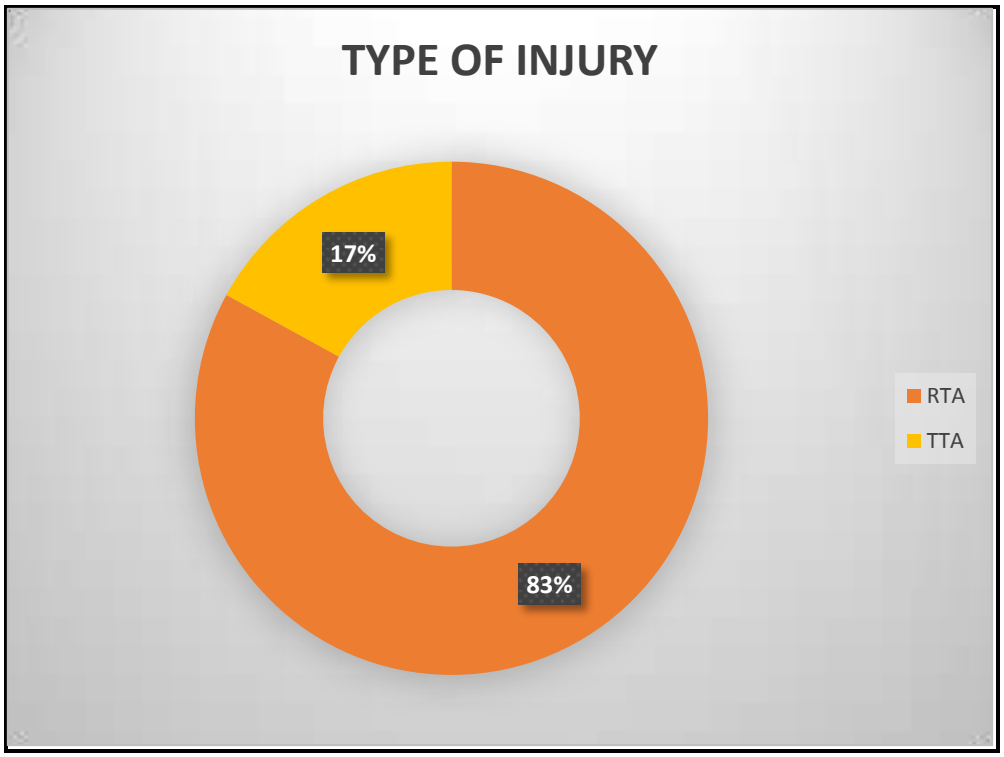
Male patients were predominant in our study. Out of 47 patients only 7 patients (15%) are female patients.



(3) Mode of Injury

Mode of injury	No of patients	Percentage
RTA	39	83%
TTA	8	17%

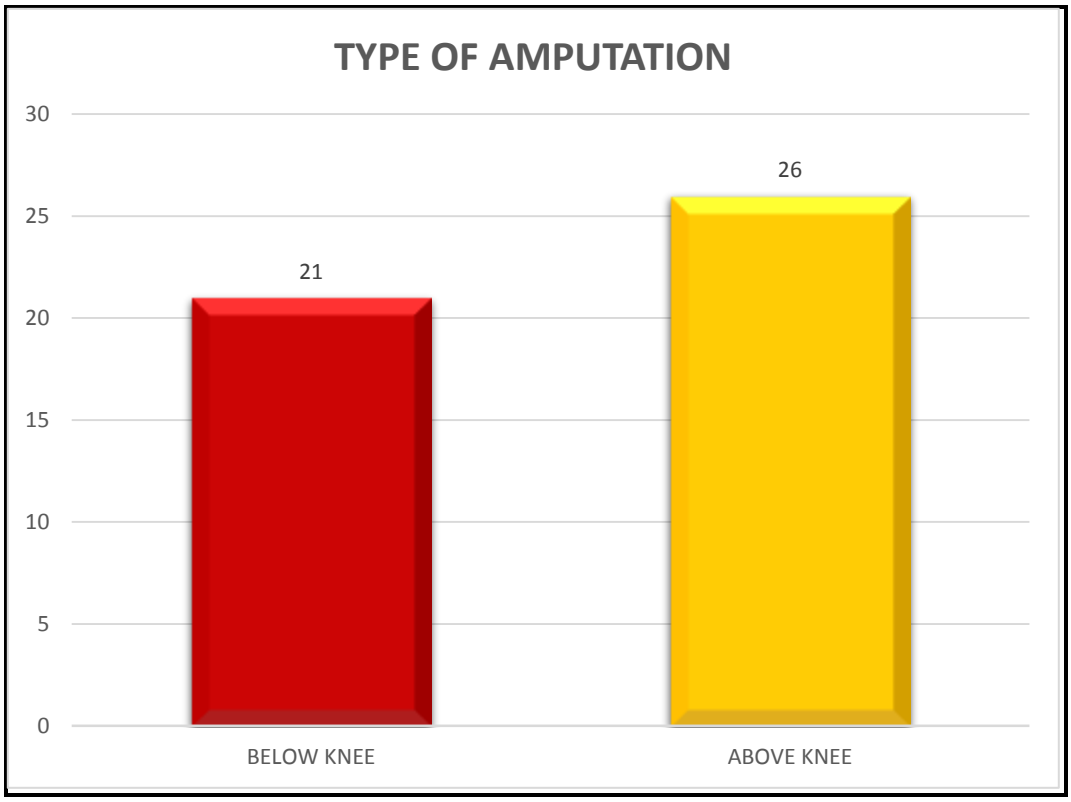
Road traffic accidents accounted for amputation in 39 patients (83%) followed by train traffic accidents in 8 (17%) patients.



(4) Type of Amputation

Type of Amputation	No of patients	Percentage
Below Knee	21	45%
Above Knee	26	55%

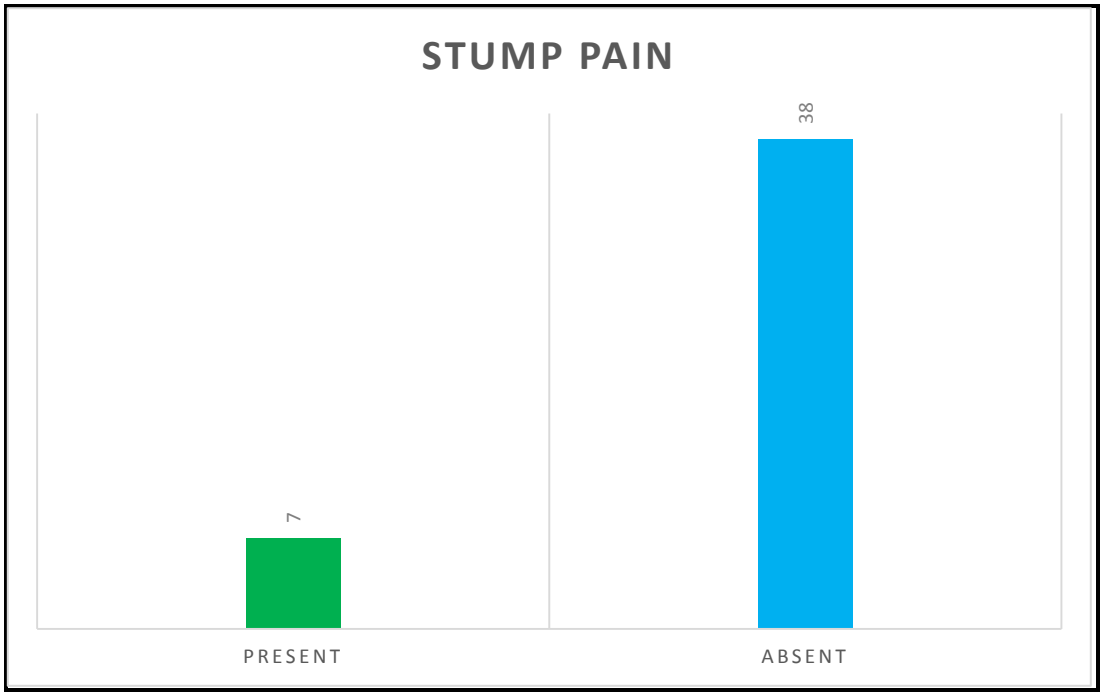
In our study, 26 (55%) patients were above knee amputees and 21(45%) were below knee amputees.



(5) Stump pain

Stump Pain	No of patients	Percentage
Present	7	15%
Absent	38	85%

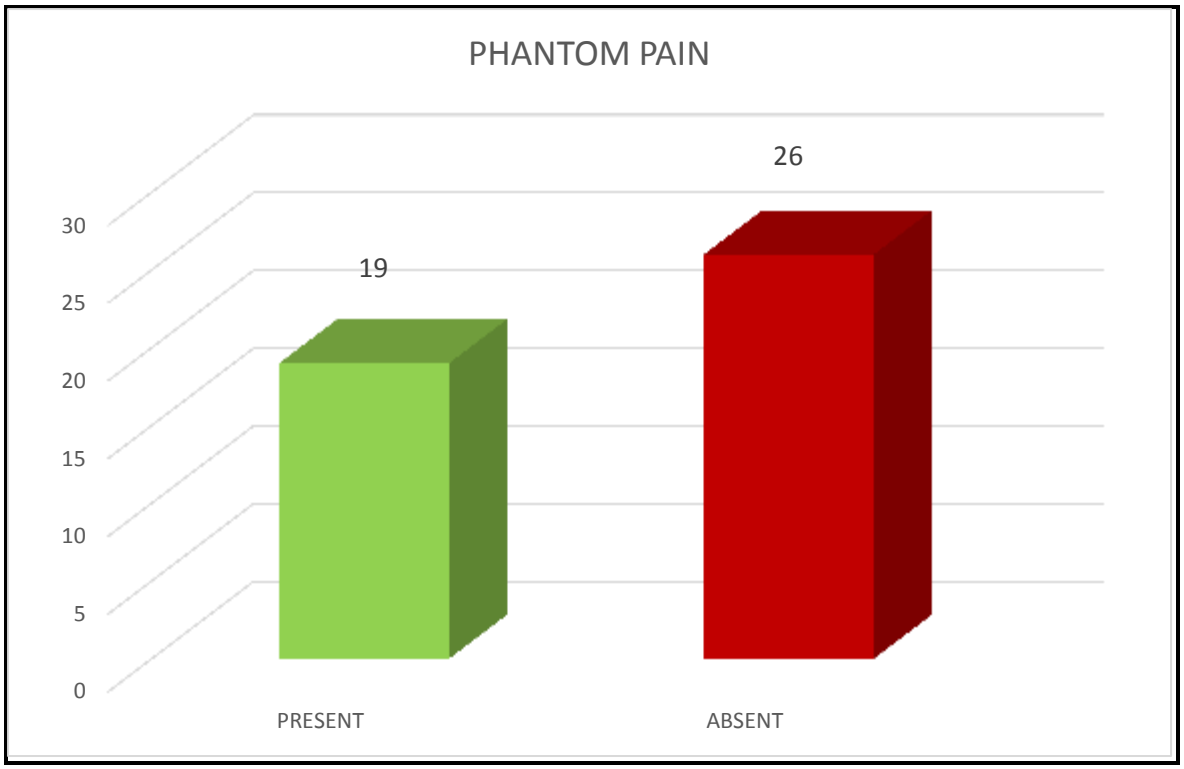
Out of 45 patients, 7 (15%) patients had stump pain.



(6) Phantom Pain

Phantom Pain	No of patients	Percentage
Present	19	42%
Absent	26	58%

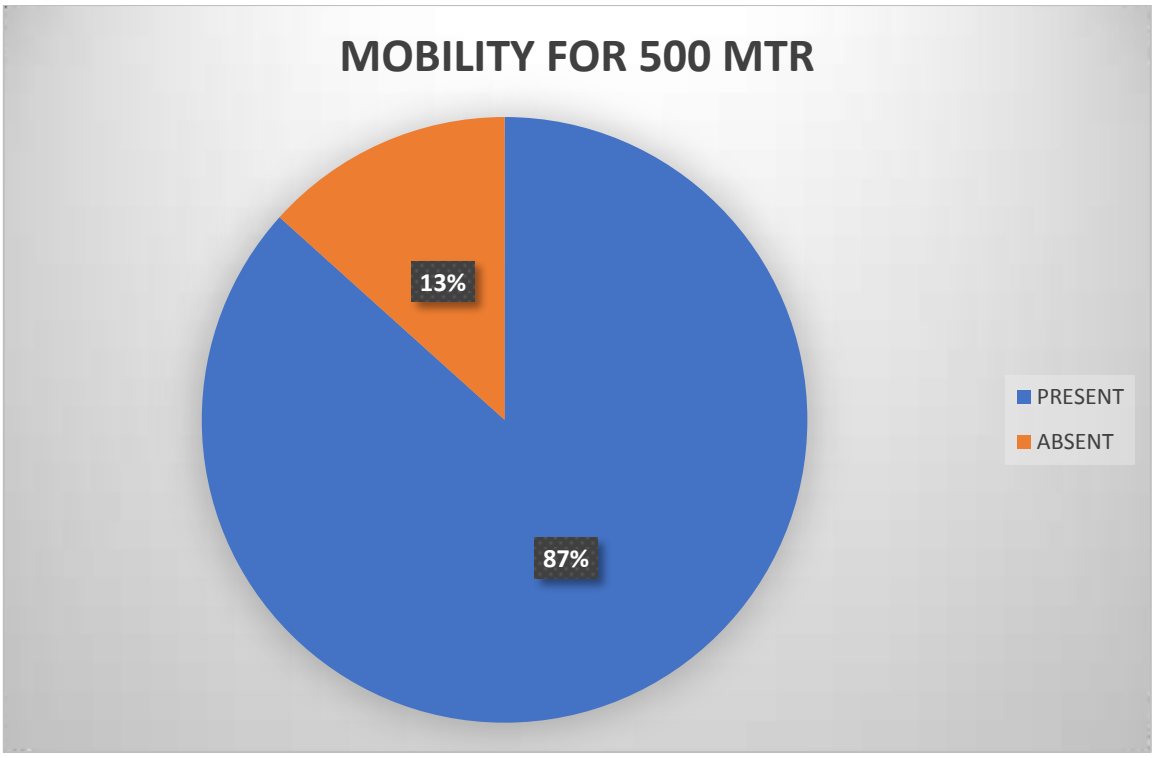
Out of 47 patients, 19(42%) patients had phantom pain.



(7) Mobility For 500 Metres

Mobility Of 500 Metres	No of patients	Percentage
Present	39	87%
Absent	6	13%

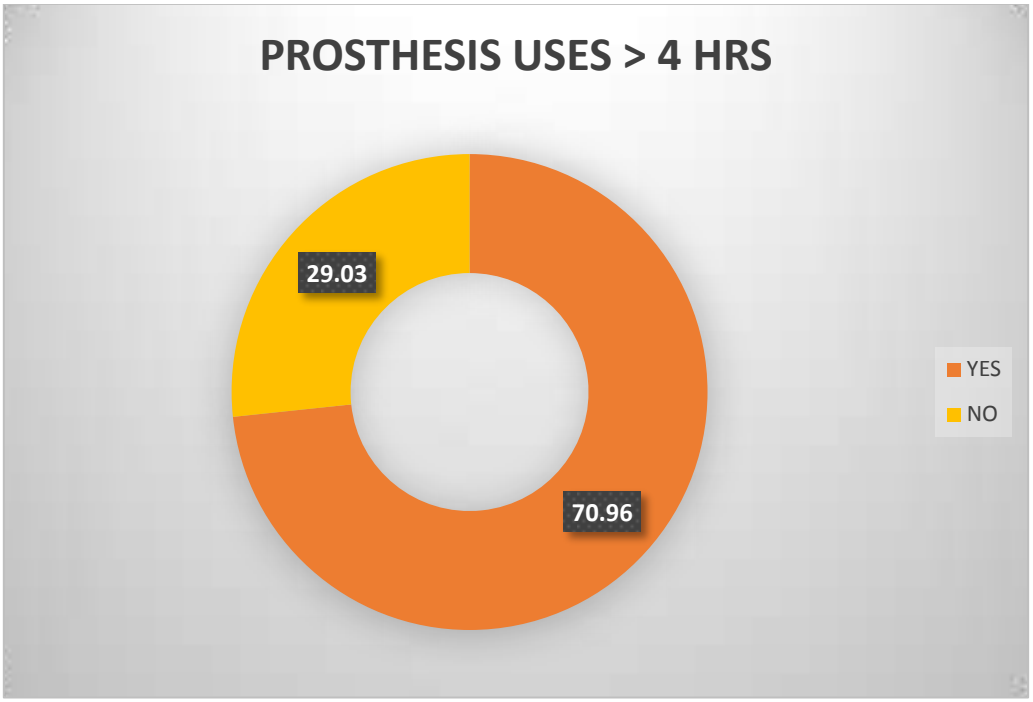
Out of 45 patients, 39 (87%) patients had mobility of more than 500 metres.



(8) Prosthesis Use for more than 4 hours per day based on gait training

Prosthesis use with gait training	No of patients	Percentage
Yes	22	70.96%
No	9	29.03%

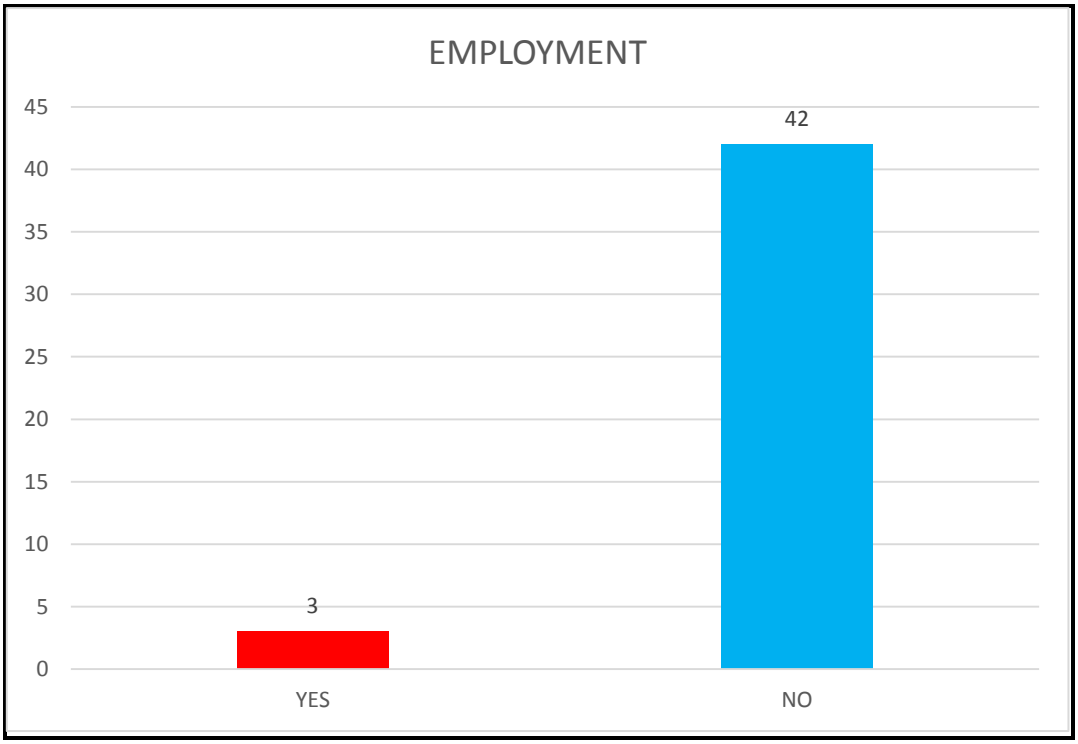
Out of 31 patients, 22 (70.96%) patients with gait training exercises were using the prosthesis for more than 4 hours per day.



(9) Employment

Employment	No of patients	Percentage
Yes	3	7%
No	42	93%

Out of 45 patients, only 3 (7%) returned to work following amputation surgery.



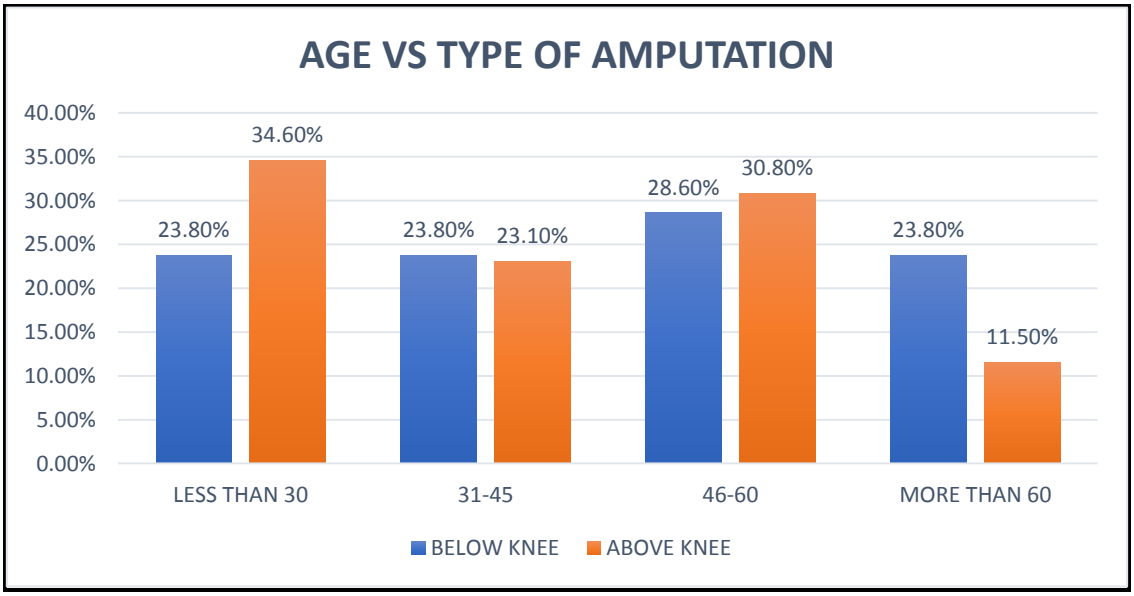
Among this 3 patients, two patients were less than 30 years of age and one patient was more than 30 years of age.

(10) Comparing age with type of amputation

Age (in years)	Type of Amputation	
	Below Knee	Above Knee
Less than 30	5(23.8%)	9(34.6%)
31-45	5(23.8%)	6(23.1%)
46-60	6(28.6%)	8(30.8%)
More than 60	5(23.8%)	3(11.5%)
Total	21(100%)	26(100%)

Out of 26 above knee amputees, 9 (34.6%) belong to <30 years age group followed by 8 (30.8%) patients in 46-60 age group.

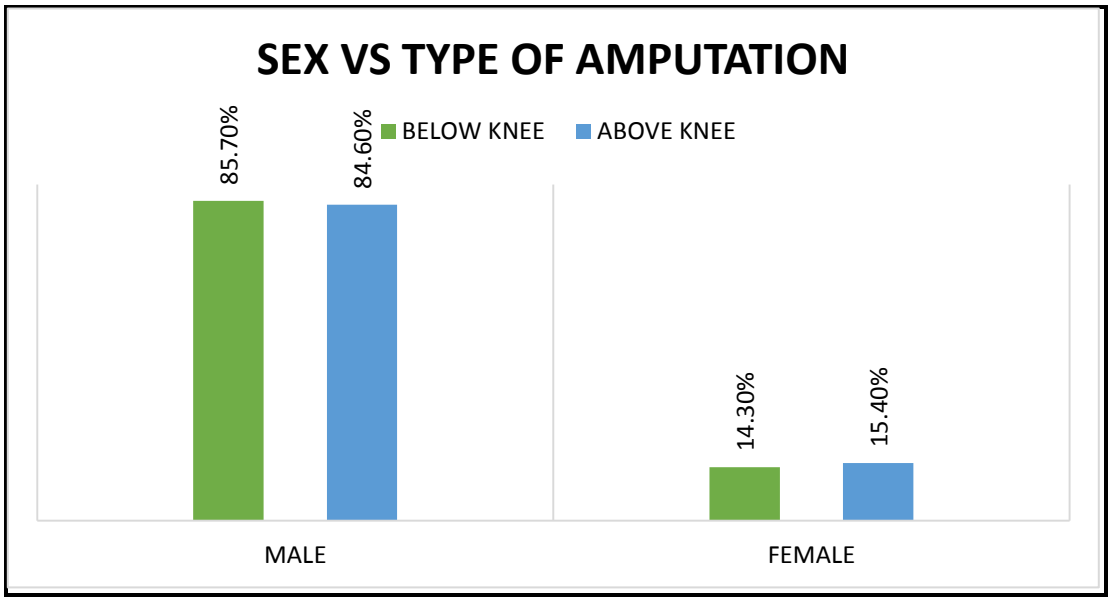
Out of 21 below knee amputees, 6 patients (28.6%) belong to 46-60 years age group.



As there is increase in age there is decrease in above knee amputation cases.

(11) Sex vs Type of amputation

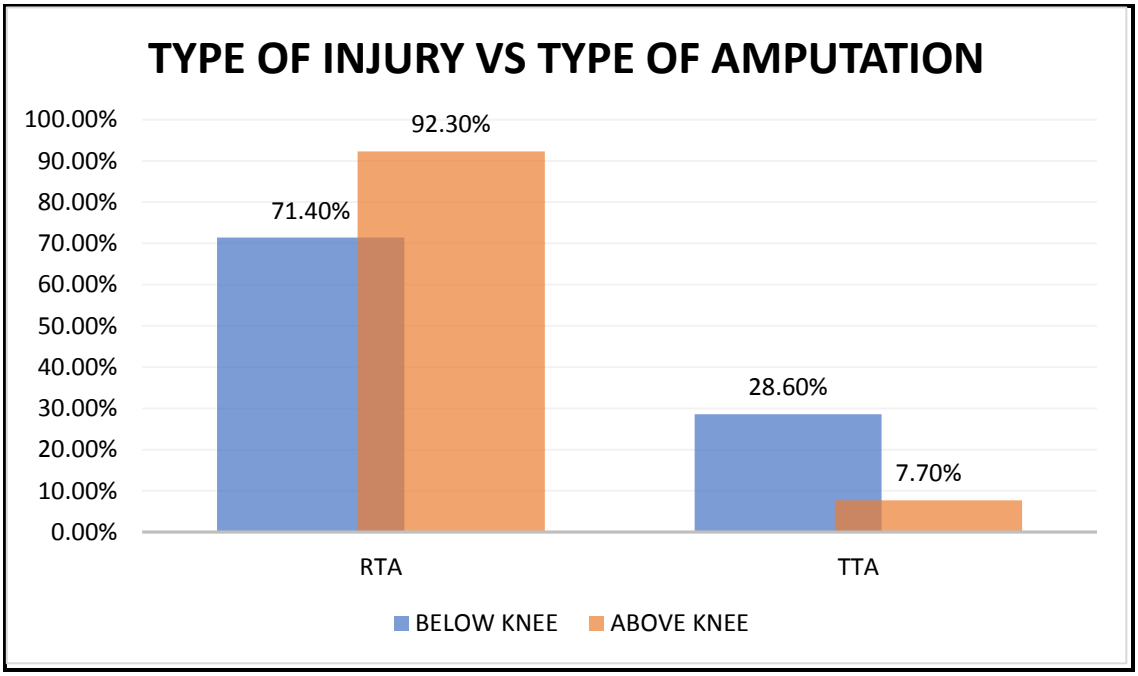
Sex	Type of Amputation	
	Below Knee	**Above Knee**
Male	18(85.7%)	22(84.6%)
Female	3(14.3%)	4(15.4%)
Total	21(100%)	26(100%)



There is not much difference between male and female patients in relation with type of amputation.

(12) Type of injury vs Type of amputation

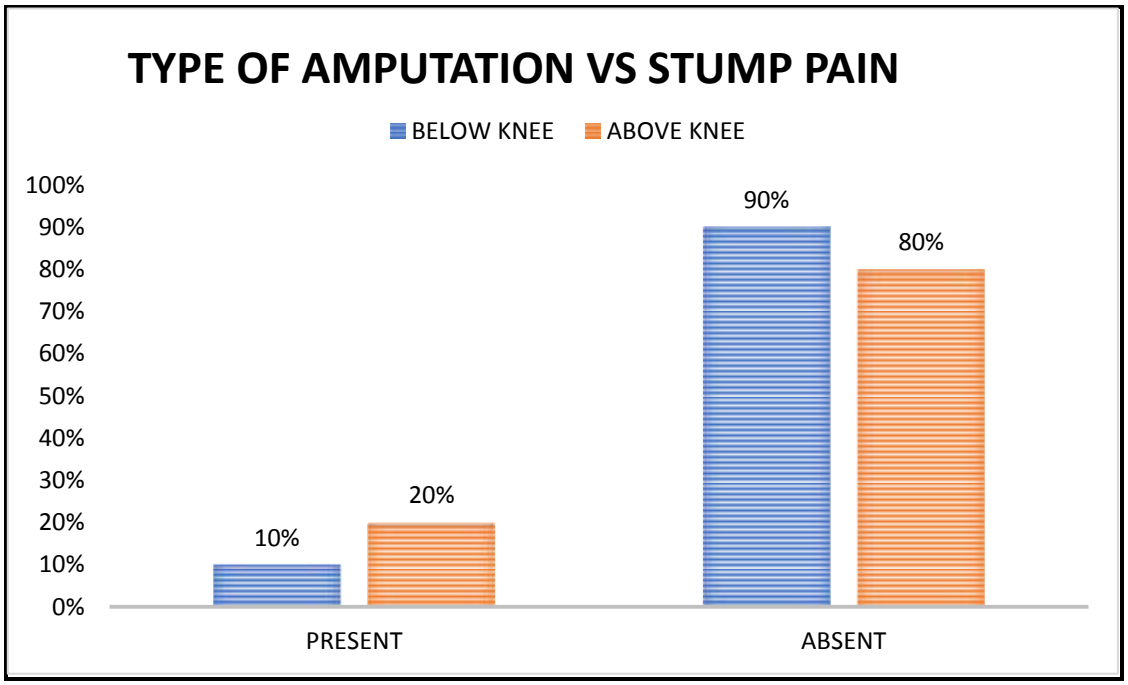
Type of Injury	TYPE OF AMPUTATION	
	Below Knee	Above Knee
RTA	15(71.4%)	24(92.3%)
TTA	6(28.6%)	2(7.7%)
Total	21(100%)	26(100%)



In our study, road traffic accidents resulted in more above knee amputation compared to train traffic accidents.

(12) Stump Pain Vs Type of Amputation

Stump Pain	Type of Amputation	
	Below Knee	Above Knee
Present	2(10%)	5(20%)
Absent	18(90%)	20(80%)
Total	20(100%)	25(100%)

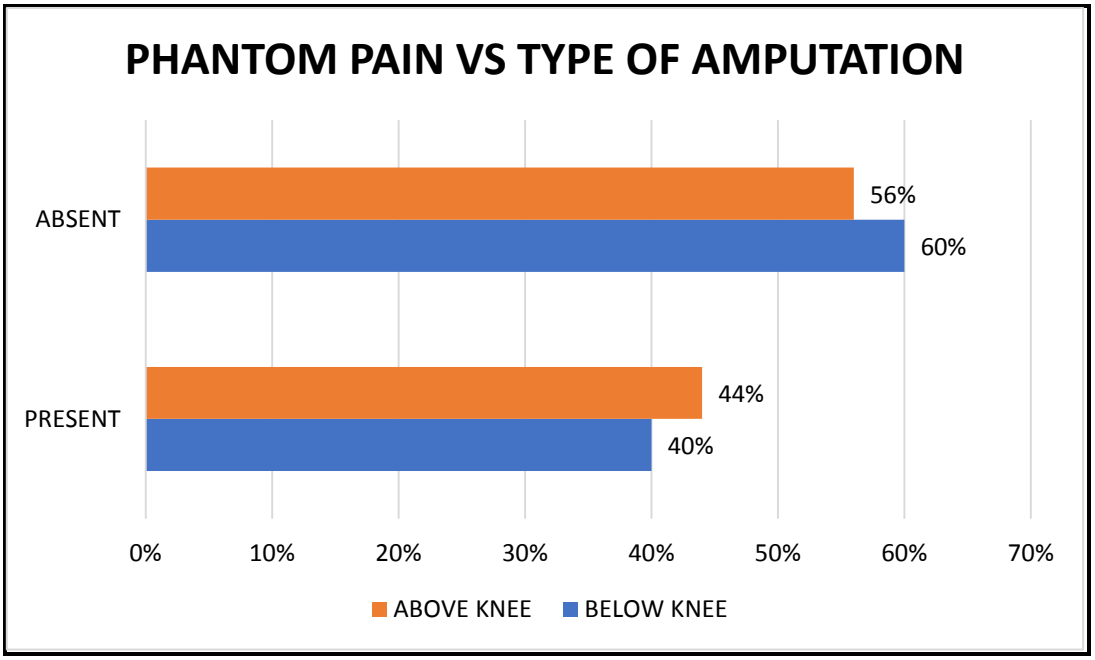


In our study, stump pain is seen much higher in above knee amputation patients compared to below knee.

(13) Phantom pain Vs Type of Amputation

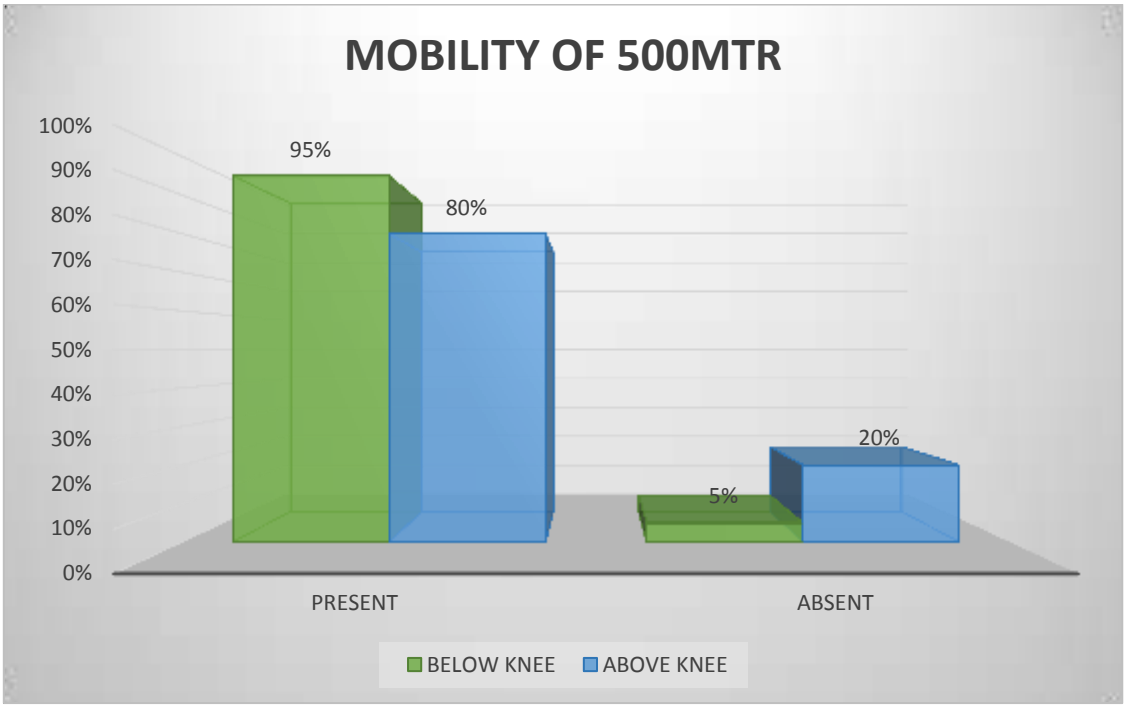
Phantom Pain	Type of Amputation	
	Below Knee	Above Knee
Present	8(40%)	11(44%)
Absent	12(60%)	14(56%)
Total	20(100%)	25(100%)

Phantom pain is seen much higher in above knee amputation compared to below knee.



(14) Mobility For 500 Metres

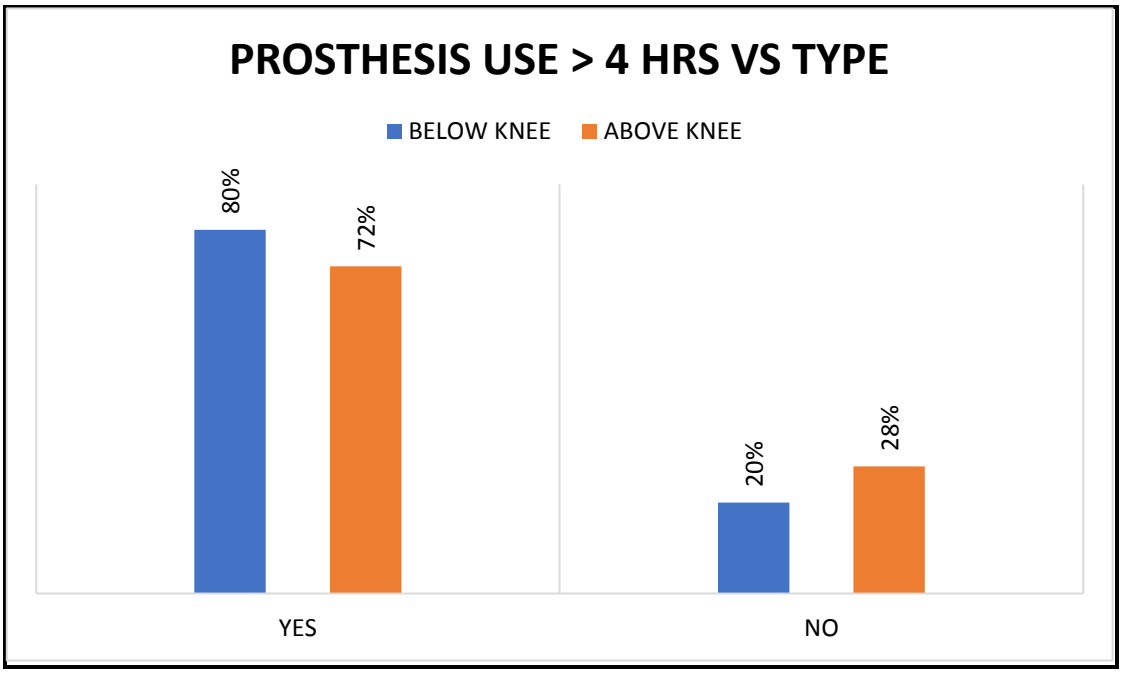
Mobility Of 500 Metres	Type of Amputation	
	Below Knee	Above Knee
Present	19(95%)	20(80%)
Absent	1(5%)	5(20%)
Total	20(100%)	25(100%)



Mobility for 500 meters is seen much higher in below knee amputation patients compared to above knee. This is statistically significant with a P value of 0.014.With an odd's ratio of 4.75 patient undergoing below knee have five times higher chance of mobility of 500 metres.

(15) Prosthesis Use For 4 Hours

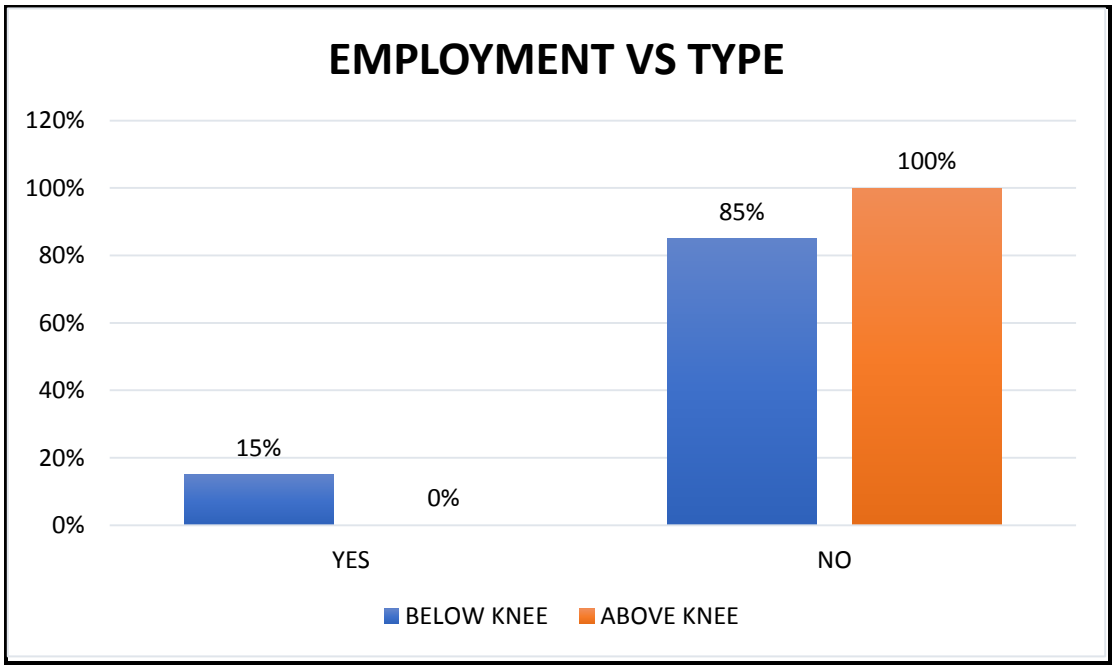
Prosthesis Use > 4 Hrs	Type of Amputation	
	Below Knee	Above Knee
Yes	17(85%)	5(45.45%)
No	3(15%)	6(54.55%)
Total	20(100%)	11(100%)



Prosthesis use for more than 4 hrs is seen much higher in below knee amputation compared to above knee. This is statistically significant with a P value of 0.21.With an odd's ratio of 1.75 patient undergoing below knee have approximately two times higher chance of using prosthesis and can sustain it for more than 4 hrs.

(16) Employment Vs Type of Amputation

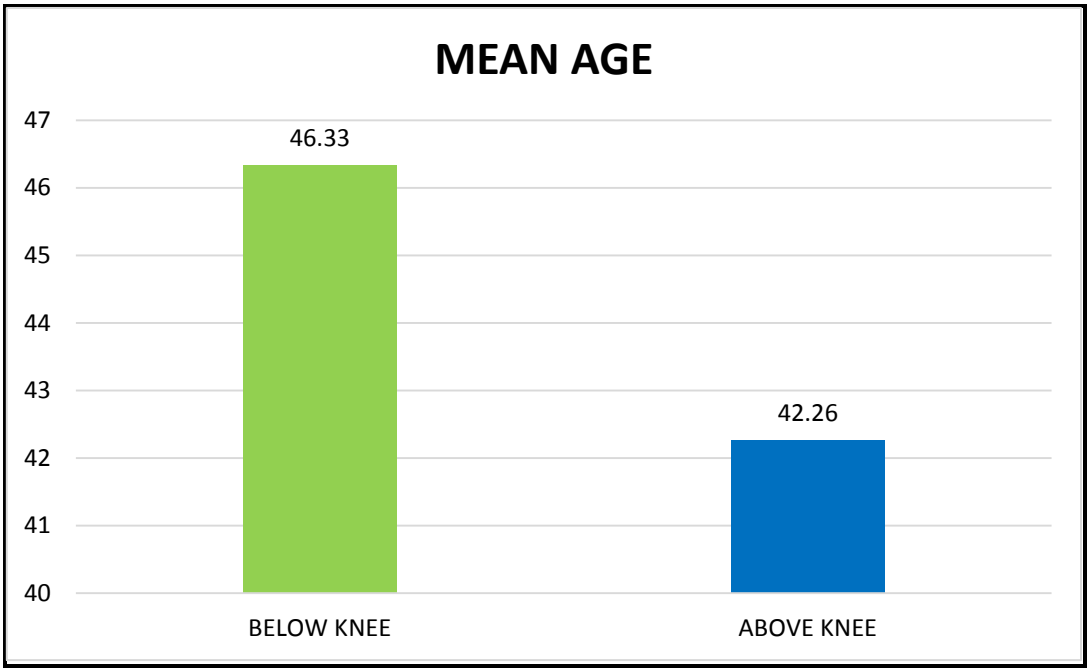
Employment	Type of Amputation	
	Below Knee	Above Knee
Yes	3(15%)	0(0%)
No	17(85%)	25(100%)
Total	20(100%)	25(100%)



All three patients who were employed belonged to below knee amputation group which is also statistically significant with an P value of 0.045.

(17) Mean Vs Type of Amputation

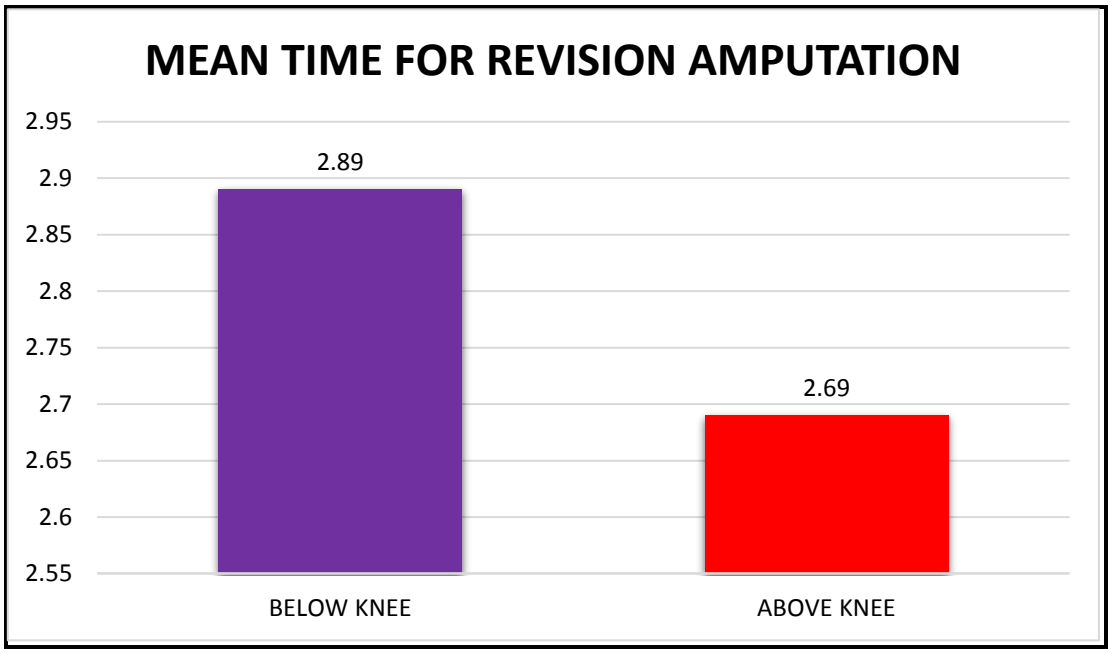
Type of Amputation	Age (In Years)	
	MEAN	SD
Below Knee	46.33	16.36
Above Knee	42.26	18.4



There is not much significant difference in mean age between below knee and above knee amputation group.

(18) Time for revision amputation

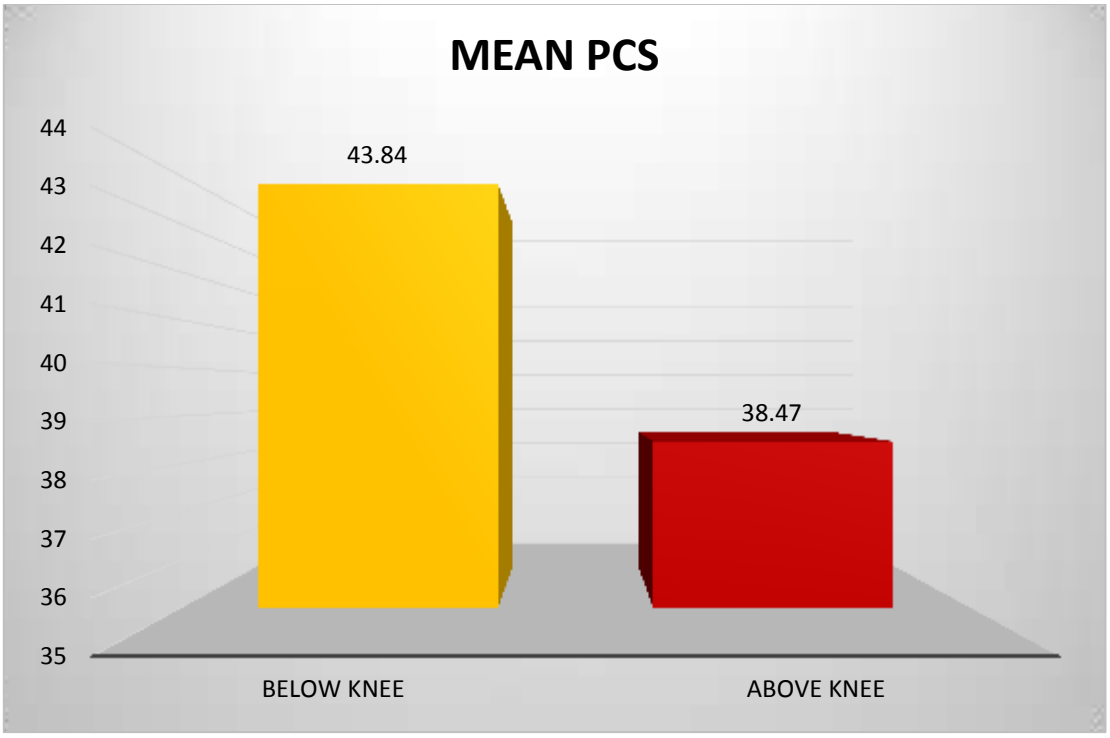
Type of Amputation	Time for Revision Amputation	
	MEAN	SD
Below Knee	2.89	1.15
Above Knee	2.69	1.01



There is not much significant difference in mean time for revision amputation between below knee and above knee amputation group.

(19) Physical Component Score

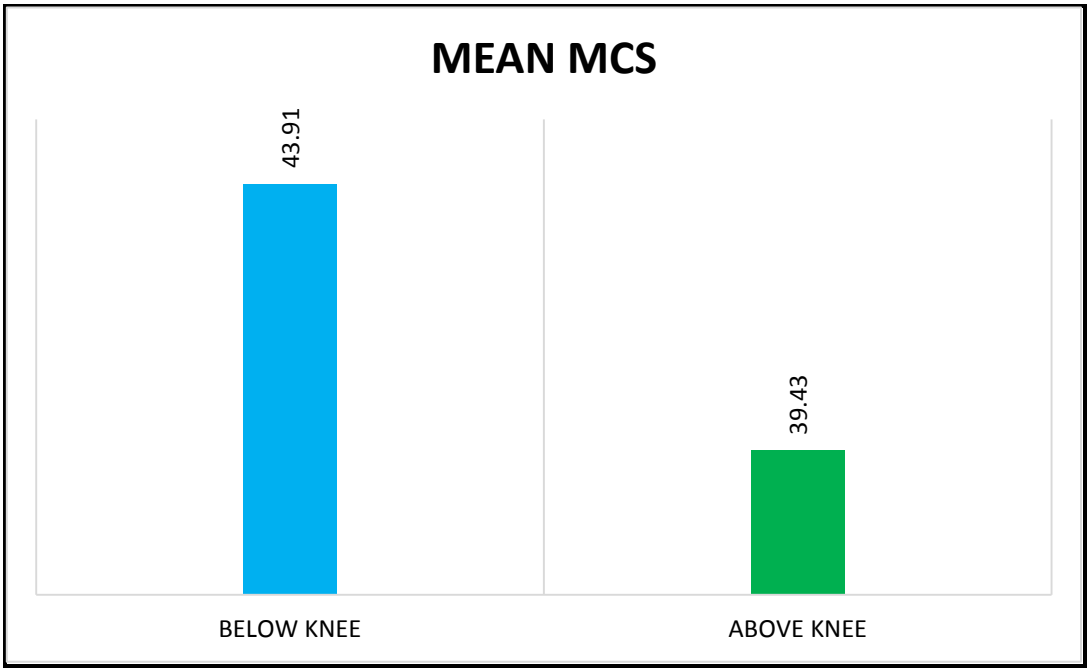
Type of Amputation	Physical Component Score	
	MEAN	**SD**
Below Knee	43.84	7.2
Above Knee	38.47	8.07
P VALUE - 0.025		
SIGNIFICANT		
UNPAIRED T TEST		



There is significant difference in Physical Component Score with below knee amputation patient had better score than above knee patients, which is also statistically significant with an P value of 0.025.

(20) Mental Component Score

Type of Amputation	Mental Component Score	
	MEAN	**SD**
Below Knee	43.91	7.89
Above Knee	39.43	6.26
P VALUE - 0.039		
SIGNIFICANT		
UNPAIRED T TEST		



There is significant difference in Mental Component Score with below knee amputation patients had better scores than above knee amputees, which is also statistically significant with an P value of 0.039.

(21) Stump length

Type of amputation	**Stump length**
	Mean
Below Knee	20.35
Above Knee	24.2

The mean stump length in 25 above knee amputees is 24.2 cm and 20 below knee amputees is 20.35 cm.

DISCUSSION

The mean age of the patient in our study was 44.08 years with range from 13 to 83 whereas Walker et al reported 30.83 years as average. Dillingham et al reported average age of 32.9 years and Pezzin et al reported mean age of 32 years. This can probably be attributed to the fact, that a tertiary care centre attracts elderly patients, as they have more comorbidities and are prone to more complications compared to the rest of the general population.

There was male preponderance in our series with 40:7, male:female ratio (85%). Walker et al reported 72:15, male: female ratio. Dillingham et al reported male dominance with 87%. Pezzin et al reported similar results of 86% with male preponderance. This reflects the pattern of trauma, with males more commonly affected than females in Indian population.

The most common mode of injury was road traffic accident with 83% followed by train traffic accident of 17%. Ghosh et al 70% of amputations were accounted due to trauma.

The number of above knee to below knee amputees was 26:21. Walker et al reported 47 below knee amputees 24 above knee and 7 cases of bilateral amputees. Pezzin et al reported 23 below knee to 10 above knee amputee cases.

Stump pain was experienced by 7 out of 47 patients. 10% of below knee amputees and 20% of above knee amputees experienced stump pain. Walker et al reported 40% of Below knee amputees and 46% of above knee amputees had stump pain. In a meta-analysis by Penn-barwell 52% of below knee amputees and 58% above knee amputees experienced painful symptoms associated with stump.

Phantom pain was experienced by 19 out of 47 patients. 40% of Below knee and 44% of above knee amputees experienced phantom pain. Walker et al reported 68% below knee and 75% above knee amputees had phantom pain. Pezzin et al reported 23% below knee and 10% above knee amputees experienced phantom pain.

95% of below knee and 72% of above knee amputees had a mobility of more than 500 metres. Walker et al reported 36% below knee and 46% above knee amputees had mobility of more than 500metres. Penn-Barwell meta – analysis revealed 75% patients with below knee and through knee amputations had a mobility of more than 500 metres. These Studies have shown that more proximal the level of amputation, worse is the mobility and concludes that maintaining of maximal limb length significantly improves the functional outcome of the patient.

15% of below knee and 54.55% of above knee amputees wear prosthesis less than 4 hours per day. Walker et al reported 4.2% of below knee and above knee amputees wear prosthesis less than 4 hours a day. In Penn-barwell meta-analysis, patients with below knee amputees wore prosthesis significantly more than above knee amputees. In our study it was found that the failure in compliance of 9 (29.03%) patients to wear prosthesis for less than 4 hours was found to correlate with those patients who failed to avail the pre-prosthetic gait training from the hospital due to various social economic barriers whereas remaining 22 (70.96%) patients availed either in-patient or out-patient gait training before prosthesis fitting. Other reasons for failure of compliance with prosthesis includes high temperature, increased sweat leading to irritation as well as pain in stump-prosthesis interface.

In my study, only 3 below knee amputees and no above knee patients were employed. However these patients were forced to pursue occupations which were more suited to their current disability. Walker et al reported 25% of below knee and 21% of above knee amputees were employed. In Penn barwell meta-analysis, 74% below knee and 70% above knee returned to work.

In our study, the mean stump length in above knee amputees is 24.2 cm and below knee amputees is 20.35 cm. Brian S. Baum et al in his study on transfemoral amputees, concluded that preservation of stump length may not be as important as other factors such as performance of myodesis, type of prosthesis and rehabilitation [36]. Koyel Majumdar et al in his study divided below knee amputees into three groups with long, medium and short stump. He concluded that patients with longer stump had more velocity and less energy expenditure compared to short stump length [37]. In our study, although our stump length didn't correlate with ideal stump length values, 85% below and 45.45% above knee amputees use prosthesis more than 4 hrs and mobility of 500 metres, which implies that ideal stump length is less important than quality of stump, prosthesis and rehabilitation.

Quality of life measured by SF12 score revealed significant lowering of physical component score (PCS) of below knee amputees (43.84) compared to that of above knees (38.47) amputees. Similarly, mental component score (MCS) revealed a lower score of above knee amputees (39.43) compared to that of above knee amputees (43.91). Meta-analysis revealed significant lowering of PCS as the amputation level becomes more proximal.

CONCLUSION

From our study,

- we conclude that below knee amputees have better quality of life than above knee amputees.
- The successful rehabilitation of an amputee on a prosthesis depends on stump quality and except for mechanical advantage of long lever arm, maintaining ideal stump length is not much important in rehabilitation of an amputee.
- Developing awareness programme among the amputees, regarding rehabilitation services like pre-prosthetic gait training exercises, early prosthetic fitting helps to improve the prosthesis use, quality of health and vocational prospects.
- Medical rehabilitation alongwith psychosocial rehabilitation by an interdisciplinary, well co-ordinated team of physiotheraist, occupational therapist, nurse, psychologist and social worker helps to attain the ultimate goal of successful re-integration of an amputee to the level of pre-amputation daily living.
- Newer developments in prosthetic interface and stump pain management significantly improves quality of life.

Case illustrations

1. Mr.Rajkumar 28/M Mode of injury: TTA

Diagnosis: Traumatic amputation at right foot

Post - Guillotine Amputation

Revision amputation at 3 weeks

2. Mr.Varadhan 55/M

Diagnosis : Grade III c compound supracondylar fracture right side

Guillotine Amputation

Revision amputation at 2 weeks

3. Mr. Sasikumar 43/M

BK amputee with BK prosthesis

4. Mr. Pandi 48/M

BK amputee with BK prosthesis

PROFORMA

Patient details :

Name : Age/Sex : IP:

Address / Ph.no:

1. Mode of injury :
2. Level of amputation :
3. Revision amputation :
4. Stump pain : Yes / No
5. Phantom pain : Yes / No
6. Duration after amputation :
7. Prosthesis availability:
8. Employment status:
9. How many hours do you wear your artificial limb without pain each day ?

   a)Less than 4 hrs b)4-8 hrs

   c)8-12 hrs d)12-16hrs

10. How far can you walk on flat without pain?

    a)Less than 50m b)50-500m

    c)500-1000 m d)>1000 m

SF-12v2™ Health Survey

Instructions: Enter the answer given by the participant for each response.

This survey asks for your views about your health. This information will help you keep track of how you feel and how well you are able to do your usual activities. Answer every question by selecting the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can.

1. In general, would you say your health is:

Excellent 1 Very good 2 Good 3 Fair 4 Poor 5

2. The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

	Yes, limited a lot	Yes, limited a little	No, not limited at all
a. **Moderate activity** such as moving a table	1	2	3
b. Climbing **several** flights of stairs *	1	2	3

[* - Questionnaire modified to suit the Indian population]

3. During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

	All the time	Most the time	Some the time	A little the time	None the time
a. Accomplished less than you would like	1	2	3	4	5
b. Were limited in the kind of work or other activities	1	2	3	4	5

4. During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

	All the time	Most the time	Some the time	A little the time	None the time
a. Accomplished less than you would like	1	2	3	4	5
b. Did work or other activities less carefully than usual	1	2	3	4	5

5. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

Not at all 1

A little bit 2

Moderately 3

Quite a bit 4

Extremely 5

6. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks…

	All the time	Most the time	Some the time	A little the time	None the time
a. Have you felt calm and peaceful?	1	2	3	4	5
b. Did you have a lot of energy?	1	2	3	4	5
c. Have you felt downhearted and depressed?	1	2	3	4	5

7. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?

All of the time	1
Most of the time	2
Some of the time	3
A little of the time	4
None of the time	5

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ஒப்புதல் படிவம்

ஆராய்ச்சி மையம்: **இராஜீவ் காந்தி அரசு பொது மருத்துவமனை மற்றும் மருத்துவக் கல்லூரி, சென்னை.**

நோயாளியின் பெயர்: நோயாளியின் வயது:

பதிவு எண்:

நோயாளி கீழ்கண்டவற்றுள் கட்டங்களை (✓) செய்யவும்

1. மேற்குறிப்பிட்டுள்ள ஆராய்ச்சியின் நோக்கத்தையும் பயனையும் முழுவதுமாக புரிந்து கொண்டேன். மேலும் எனது அனைத்து சந்தேகங்களையும் கேட்டு அதற்கான விளக்கங்களையும் தெளிவுபடுத்திக் கொண்டேன்.
2 மேலும் இந்த ஆராய்ச்சிக்கு எனது சொந்த விருப்பத்தின் பேரில் பங்கேற்கிறேன் என்றும், மேலும் எந்த நேரத்திலும் எவ்வித முன்னறிவிப்புமின்றி இந்த ஆராய்ச்சியிலிருந்து விலக முழுமையான உரிமை உள்ளதையும், இதற்கு எவ்விட சட்ட பிணைப்பும் இல்லை என்பதையும் அறிவேன்.
3 ஆராய்ச்சியாளரோ, ஆராய்ச்சி உதவியாளரோ, ஆராய்ச்சி உபயத்தாரோ, ஆராய்ச்சி பேராசிரியரோ, ஒழுங்குநெறி செயற்குழு உறுப்பினர்களோ எப்போது வேண்டுமானாலும் எனது அனுமதியின்றி எனது உள்நோயாளி பதிவுகளை இந்த ஆராய்ச்சிக்காகவோ அல்லது எதிர்கால பிற ஆராய்ச்சிகளுக்காகவோ பயன்படுத்திக் கொள்ளலாம் என்றும், மேலும் இந்த நிபந்தனை நான் இவ்வாராய்ச்சியிலிருந்து விலகினாலும் தகும் என்றும் ஒப்புக் கொள்கிறேன். ஆயினும் எனது அடையாளம் சம்பந்தப்பட்ட எந்த பதிவுகளும் (சட்டப்பூர்வமான தேவைகள் தவிர) வெளியிடப்படமாட்டாது என்ற உறுதிமொழியின் பெயரில் இந்த ஆராய்ச்சியிலிருந்து கிடைக்கப்பெறும் முடிவுகளை வெளியிட மறுப்பு தெரிவிக்கமாட்டேன் என்று உறுதியளிக்கிறேன்
4 இந்த ஆராய்ச்சிக்கு நான் முழுமனதுடன் சம்மதிக்கிறேன் என்றும் மேலும் ஆராய்ச்சிக் குழுவினர் எனக்கு அளிக்கும் அறிவுரைகளை தவறாது பின்பற்றுவேன் என்றும் இந்த ஆராய்ச்சி காலம் முழுவதும் எனது உடல் நிலையில் ஏதேனும் மாற்றமோ அல்லது எதிர்பாராத பாதகமான விளைவோ ஏற்படுமாயின் உடனடியாக ஆராய்ச்சி குழுவினரை அணுகுவேன் என்றும் உறுதியளிக்கிறேன்.
5 இந்த ஆராய்ச்சிக்குத் தேவைப்படும் அனைத்து மருத்துவப் பரிசோதனைகளுக்கும் ஒத்துழைப்பு தருவேன் என்று உறுதியளிக்கின்றேன்.
6 இந்த ஆராய்ச்சிக்கு யாருடைய வற்புறுத்தலுமின்றி சொந்த விருப்பத்தின் பேரிலும் சுய அறிவுடனும் முழுமனதுடனும் சம்மதிக்கிறேன் என்று இதன் மூலம் ஒப்புக் கொள்கிறேன்.

நோயாளியின் கையொப்பம்/ பெருவிரல் ரேகை

ஆராய்ச்சியாளரின் கையொப்பம்

இடம்:

தேதி:

MASTER CHART

Name	Age	Sex	Mode of Injury	Level of amputation	Revision amputation	PCS	MCS	Stump pain	Phantom pain	Mobility of 500m	Prosthesis use >4 hours	Employment	Referral time (injury to surgery)	Stump length
Ramasamy	83	M	RTA	AK	2 weeks	40.423749	36.64734	No	Yes	No	No	No	6 hrs	21
Somu	45	M	RTA	AK	2	53.257044	28.73963	No	No	Yes	Yes	No	3 days	27
Sasikala	36	F	RTA	AK	4	27.470104	34.93555	Yes	Yes	No	No	No	7 hrs	33
Sivaraj	27	M	RTA	AK	5	30.705655	33.79967	Yes	Yes	No	No	No	9 hrs	32
Manikandan	19	M	TTA	AK	2	45.458566	30.97771	No	No	Yes	Yes	No	7 hrs	23
Somasundaram	39	M	RTA	AK	2	44.384666	33.40481	No	No	Yes	Yes	No -	3 days	22
Subramani	57	M	RTA	BK	4	28.923526	41.46622	No	No	No	No	No	2 days	8
Narasiman	24	M	RTA	BK	2	36.91437	35.10148	Yes	Yes	Yes	No	No	1 day	20
Samuvel	45	M	RTA	AK	2	40.742581	35.38029	No	No	Yes	Yes	No	2 days	23
Chengaiyah	23	M	RTA	AK	2	35.087186	41.76052	No	Yes	Yes	Yes	No	4 hrs	19
Mani	65	M	RTA	BK	4	45.471979	42.87654	No	Yes	Yes	Yes	No	3 hrs	17
Varadhan	55	M	RTA	AK	2	25.340434	42.69224	Yes	yes	Yes	Yes	No-	9 days	22
Jagadheesh	54	M	RTA	AK	3	37.05416	41.01627	No	Yes	Yes	Yes	No-	9 hrs	26
Rajkumar	28	M	TTA	BK	3	38.250433	32.21478	No	Yes	Yes	Yes	NO	1 hr	22
Veeraraghavan	69	M	RTA	AK	2	43.328896	38.7344	No	Yes	Yes	Yes	No	6 hrs	24
Datchanamoorthy	18	M	RTA	AK	2	36.782781	41.55057	No	No	Yes	No	No	6 hrs	22
Sasikumar	43	M	TTA	BK	2	56.432722	59.99686	No	No	Yes	Yes	Yes	4 hrs	12
Kuppan	72	M	RTA	BK	4	56.293068	33.7643	No	No	Yes	Yes	No	5 days	14
Giribabu	35	M	RTA	AK	4	43.978797	34.38855	No	No	Yes	Yes	No-	1 day	32
Thirumal	23	M	RTA	BK	2	52.246184	48.73427	No	No	Yes	Yes	Yes	4 days	22
Mani	65	M	RTA	BK	2	51.364064	47.07194	No	No	Yes	Yes	Yes	5 days	28
Kuppusamy	67	M	RTA	AK	4								8 hrs	
Geetha	40	F	TTA	BK	6	48.161894	45.58189	No	No	Yes	Yes	No	10 hrs	24

Name	Age	Sex	Mode of Injury	Level of amputation	Revision amputation	PCS	MCS	Stump pain	Phantom pain	Mobility of 500m	Prosthesis use >4 hours	Employment	Referral time (injury to surgery)	Stump length
Vedha	42	F	RTA	BK	4	35.327473	29.2085	Yes	Yes	Yes	No	No-	5 hrs	18
Gomathy	21	F	RTA	AK	2	39.12414	35.80408	No	No	Yes	No	No	2 days	21
Sasikala	36	F	RTA	AK	2	23.144759	41.45154	Yes	Yes	No	No	No-	3 hrs	20
Dhanasekar	54	M	RTA	AK	4	32.060929	48.52366	Yes	Yes	Yes	Yes	No-	1 day	25
Subramani	65	M	RTA	BK	2	41.036512	40.19537	No	Yes	Yes	Yes	No	6 days	20
Pandi	48	M	TTA	BK	2	41.160478	45.38813	No	No	Yes	Yes	No	1 day	17
Kannan	27	M	RTA	AK	2	34.058897	29.60014	No	No	Yes	Yes	No	7 days	22
Govindaraj	48	M	RTA	BK	3								3 days	
Varadhan	55	M	RTA	AK	2	41.851226	44.53414	No	No	Yes	Yes	No	3 days	24
Subramani	66	M	RTA	BK	4	49.009968	49.72601	No	No	Yes	Yes	No	9 hrs	12
Anandhan	20	M	TTA	BK	2	44.270983	50.52458	No	No	Yes	Yes	No	4 days	8
Yesudass	53	M	RTA	AK	4	41.775189	47.24804	No	No	Yes	Yes	No	3 days	21
Perumal	40	M	RTA	BK	3	48.202577	50.91729	No	No	Yes	Yes	No-	6 hrs	27
Ramalingam	60	M	RTA	BK	No	36.899763	46.38609	No	No	Yes	No	No	5 hrs	22
Selvam	27	M	RTA	AK	2	48.526132	50.8037	No	No	Yes	Yes	No	2 hrs	23
Karthik	24	M	RTA	AK	4	48.740912	50.31829	No	No	Yes	Yes	No	3 hrs	25
Narayanan	47	M	RTA	BK	No	45.311453	48.60285	No	No	Yes	Yes	No-	2 days	12
Mayan	54	M	TTA	AK	2	38.593575	43.10425	No	No	Yes	Yes	No-	10 days	22
Manoharan	21	M	RTA	BK	2	38.592909	42.9601	No	Yes	No	No	No	15 days	26
Shantha	42	F	RTA	BK	2	41.14845	34.39655	No	Yes	Yes	Yes	No	6 hrs	20
Sheeba	13	F	RTA	AK	2	41.697967	36.01612	No	Yes	Yes	Yes	No	1 day	25
Majith Bai	60	M	RTA	AK	4	22.869939	39.00011	No	Yes	No	No	No	5 hrs	27
Rajendran	57	M	TTA	BK	2	41.862611	53.2855	No	Yes	Yes	Yes	No	12 days	28
Mayakrishnan	60	M	RTA	AK	2	45.513764	45.51914	No	No	Yes	Yes	No	8 hrs	24